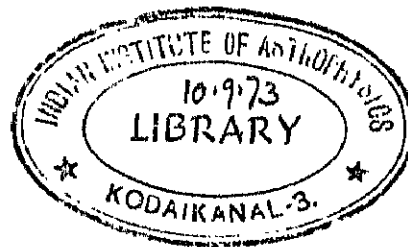


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ATOMIC FORCES
IN CELESTIAL BODIES

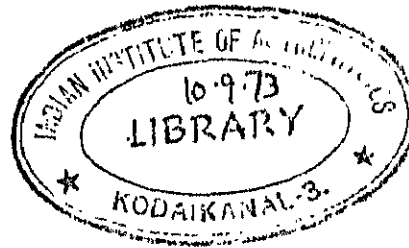
ATOMIC FORCES IN CELESTIAL BODIES

To account for Observed Phenomena of the Sun,
the Major Planets, the Moon, the
Earth, and the Stars

By

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PREFACE

The figures of rotating celestial bodies have been discussed with mathematical precision by several authors, of whom, perhaps Poincaré and Darwin are the most frequently quoted. Their procedure was to make certain assumptions with respect to the rate of rotation and of the distribution of density in the mass of a celestial body, and on this basis to derive the equipotential surface which would be in coincidence with the body's outer surface. Thus the equations derived for the figures of celestial bodies under the different assumed conditions are actually those of equipotential surfaces in a resultant field of force whose component fields are those due respectively to rotation and gravitation.

If other forces are present or the conditions assumed with respect to rotation and the distribution of density are not fulfilled, then the equipotential surface derived will not be the actual figure of the rotating body. It is significant that the discussions deal primarily with the forces to which particles in the configuration are subject, and that the equipotential surface derived represents a definite alignment of the forces in the resultant field in each case considered.

The authors of these discussions regarded a celestial body as made up of concentric homeoids of matter whose densities are greater in consecutive order toward the center of mass. It is a presumption of the present discussion that within a homeoid reasonably near the outer surface the conditions of temperature, pressure, and electrification are such that its component atoms undergo a rapid disintegration. The energies released through this atomic dissolution create mechanical forces in the homeoid whose reactions completely modify the sequence of figures derived for the celestial body on the basis of rotation and gravitation alone. It is proposed in this discussion to show how a celestial body reacts in transferring the released atomic elements to the outer surface, how the figure of the rotating body is modified by the transfer, and how the kinetic and electrical energies of the atomic particles transported are utilized to renew the body's radiant energy.

Elliott S. Smith

Cincinnati, Ohio
January 31, 1935

CONTENTS

Chapter		Page
	PREFACE	v
	INTRODUCTION	xi
I	Eruptions	1
II	The Sun	12
III	Jupiter and Saturn	19
IV	The Moon	25
V	The Earth	29
VI	The Stars	52

LIST OF ILLUSTRATIONS

Figure		Page
Frontis-piece	Twenty-four-hour Development of Sun-spot, August 18 and 19, 1916. (Mount Wilson Observatory)	
1	Units of Structure	2
2	Conditions for Surface Eruptions	2
3	The Surface Eruption	4
4	Conditions for A Sub-surface Eruption	4
5	Beginning a Sub-surface Eruption	5
6	The Fully Developed Sub-surface Eruption	6
7	Diagram	6
8	Diagram	8
9	Diagram	8
10	The Disintegration and Movement of Polar Caps	10
11	Forces Modified by Homeoidal Vibrations	11
12	The Course of an Erupting Column	12
13	Double Sun-spot Development (following)	12
13:D	Oppositely Directed Vortical Motions and Polarities in Sun-spots (following)	12
14	Bi-polar Sun-spot Group (following)	14
15	The Sun's Magnetic Field	14
16	Spot Distribution	16
16:D	Sun-spot Curve	16
17	Four Calcium Spectroheiliograms of a Single Sun-spot Cycle (following)	18
18	Four Actinic Photographs Corresponding to a Single Eruptive Cycle of Jupiter (following)	18
19	Four Photographs of Jupiter (following)	20
19:D	Jupiter's Sub-surface Eruptions (following)	20
20	Accelerating Forces	23
21	Saturn; Saturn's Ring	23
22	Lunar Eruption Features	25
23	Theophilus (following)	26
23:D	Effects of Forces (following)	26
24	Lunar Apennine Mountains Bordering the Imbrium Basin (following)	26
25	Scorings on the Moon's Surface from the Direction of Mare Imbrium (following)	26
26	Depositions, as Evidenced in Guttemberg, b (following)	28
27	Gibbous Moon (following)	28
28	The Sub-surface Eruption (following)	30
29	Mountain Folding and Lava Tubes (following)	30
30	Zones of Eruption, and of Deposition	34
31	Lava Beneath the Polar Caps	35
32	The Pacific Area (following)	36
32:D	Invasion (following)	36
33	The Atlantic Area (following)	36
34	Beginning of Polar Cap Disintegration	37
35	Earthquakes of Europe, Asia, and the Pacific Area (following)	40
36	Terrestrial Coordinates Referred to the Original Pole, Volcanoes of Europe, Earthquakes of the Pacific Coast. (following)	42
37	Deposition and Mountain-folding (following)	44
37:D	Mountain-folding (following)	44

List of Illustrations (Continued)

Figure		Page
38	Order of Excavation	47
39	The South Polar Cap Reassembly (following)	50
40	Variations Due to Sub-surface Eruptions	54
41	Nova Persei	56
42	Orbit of Sirius	61
43	Orbit of Xi Ursae Majoris	62

INTRODUCTION

The mathematicians who discussed the figures of rotating bodies were not concerned, primarily, in knowing whether the conditions assumed were ever fulfilled or not, but in making their demonstrations rigidly exact, once the assumptions were made. Some authors, in more recent times, have gone a step further and have permitted the inference to be made that a rigid mathematical discussion makes the original assumptions probable and places the conclusions drawn from them in the category of laws of nature.

An example of this type of discussion is that dealing with the gaseous star. On the presupposition that a star is a gas subject to the laws of fluids as known to physics and adapted--presumably--for the extreme conditions of temperature and pressure found in a star, a very beautiful discussion may be derived. The objection raised is not with the discussion, per se, but with the implication that all the conditions to which a star is subject were fully stated and completely considered in the discussion. As a matter of fact, the gaseous star fails to account for the most significant activity of the nearest star, the sun; namely, for sun-spots and their cycle of changes. Recent observations are making it more completely apparent that the sun is a giant electrical machine producing high potentials which vary in a regular sequence with the time, and subject the particles composing the sun to their varying control. Any conclusion with respect to the behavior of the gases which enter into the composition of a star is incomplete without a statement of the modifications they undergo by being subject to the star's induced electrical field.

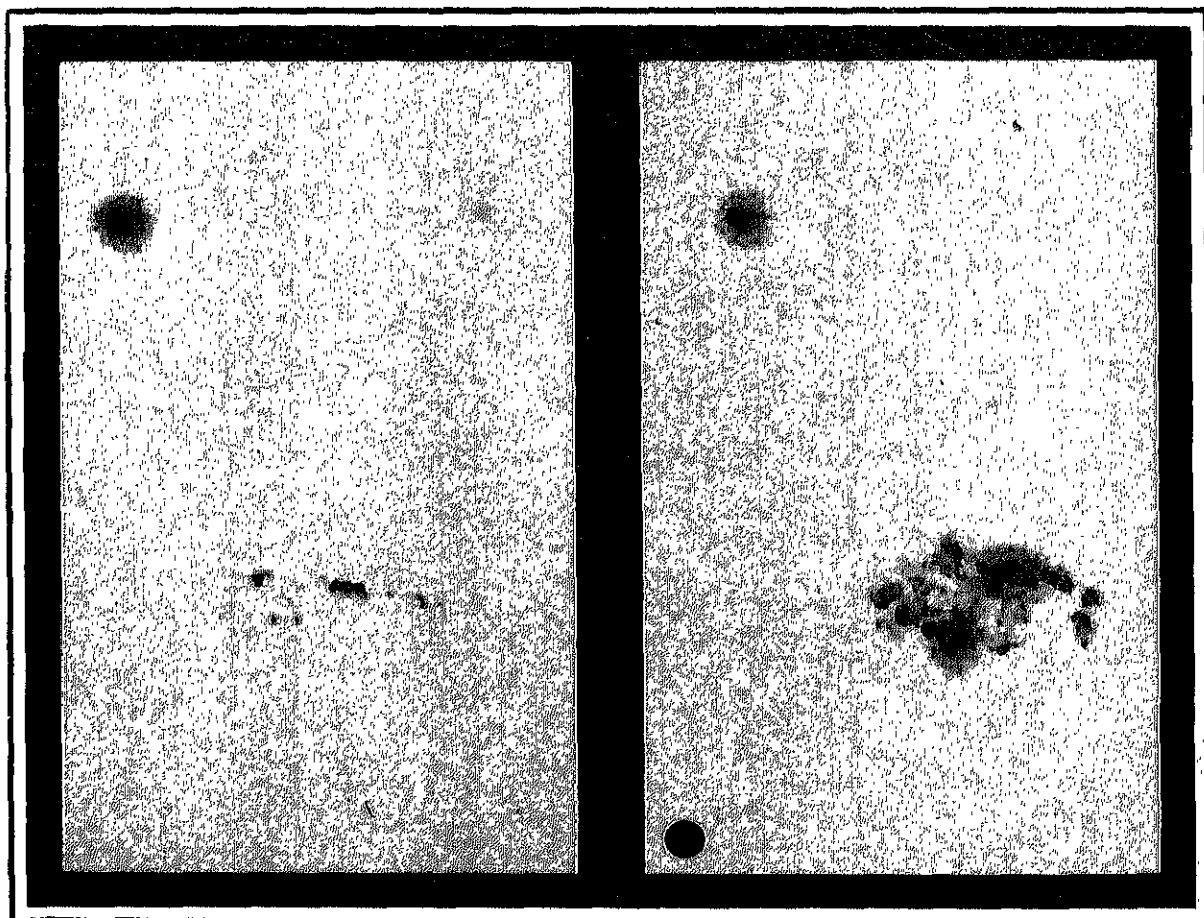
Similar misinterpretations are found in the conclusions of historical geology. For example, in complete disregard of the dynamic possibility of such a condition, it is stated in many textbooks on geology that Wisconsin at a former epoch occupied a deep sea area far removed from land. The inference is based upon the finding of extensive marine deposits in the state and in assuming that the only manner in which they could have attained their present positions was by deposition from water. The fallacy lies in failing to recognize the possibility of their having been transported from the place of their actual deep sea deposition to the Wisconsin area where found.

Suffice it to say that a mathematical discussion, however skilfully carried out, does not insure the correctness of original assumptions nor validate conclusions from them. Nor does a marine fossil tell the whole story of historical geology.

In a new and rapidly expanding science such as astrophysics, it is a valid procedure to submit its hypotheses and conclusions to the scrutiny of adverse criticism, where there appears to be clear evidence of their inadequacy. Such a procedure, it may be stated, does not deny that the hypotheses in question have been of value to the science. In fact the relationships shown to exist among dependent phenomena could hardly have been brought to light without the discussions carried out with respect to them.

The retardation to the science lies in having discussions which were put forward as tentative hypotheses, adopted out of hand as statements of actual physical relationships, without an open mind with respect to their possible inadequacy. The present discussion presumes to point out some of the shortcomings of present-day hypotheses in the two sciences of astronomy and geology.

The formidable title, THE HYPOTHESIS OF ERUPTIONS, provides a logical approach to the criticisms in question and admits the possibility of offering plausible explanations of relationships whose causes, so far, have appeared to be obscure.



Mount Wilson

The Development of a Sun-spot in Twenty-four Hours; 1916,
August 18 and 19 (Scale: Disc Represents the Earth)

CHAPTER I

ERUPTIONS

1. Purpose and Procedure

The Hypothesis of Eruptions is advanced to account for certain observed phenomena of celestial bodies. Since its validity will depend in a large measure upon the correspondence of its essential deductions with the observations appertaining to them, the plan has been followed in this discussion of making a direct comparison between deduction and observation as the hypothesis is developed. A brief introductory discussion of the hypothesis in the first chapter is followed by its specific application in later chapters, in which a more complete statement is made of the principles involved. The concomitant mathematical and physical developments have been introduced only at such points and in such measure as seems essential to a logical statement of the hypothesis.

The Hypothesis in Brief.-- A rotating celestial body of sufficient mass and angular velocity, whether it be the sun, planet, or a star, will develop a system of smaller bodies revolving in orbits about it. The particles of which they are composed and the angular momentum which maintain them in their respective orbits will have been derived from the parent body through the agency of its eruptive activities, with a corresponding decrease in its mass and angular momentum. It follows that the planets have been derived from the sun through its eruptive activity, and the satellites from their respective planets. It is proposed, in this discussion, to trace the changes and reactions which occur in a rotating celestial body from its condition as a globe of freely moving particles sustained in the configuration by their individual kinetic and electrical energies, through its condition as a satellite-forming body, to that of a rotating solid no longer in eruption.

The Orbital Assembly of Particles.-- the actual congregation of particles in

space, they will approach the center of mass of the configuration with orbital velocities that will carry them around rather than through it. A few particles might move radially back and forth through the central point, but most of them will describe orbits about it and be sustained by their individual kinetic energies. In this stage of assembly the configuration will be a hollow spherical shell that will eventually be filled with particles as they yield up their velocities through mutual impact.

Orbits will be described in all planes with motions both direct and retrograde. In general, there will be one plane in which orbital momenta predominate by virtue of an excess of particles moving in the same direction. As continuous impact accomplishes a redistribution of the particles and the configuration takes on the attributes of an organization, this plane becomes the equatorial plane of the rotating body. Following the orbital stage of assembly there will be that in which the configuration develops into an organized body whose successive homeoids are sustained by the kinetic energies of their respective particles, and in which densities increase from the surface toward the center.

A Central Globe and Radiating Shell.-- In such a body, particles at the surface, upon giving up their kinetic energies as radiant energy, conjoin into groups and form minute solids which move along gravitational lines of force to that inner concentric shell whose density is sufficient to maintain them in suspension. As radiation continues, this shell increases in thickness, tenacity, and density and eventually becomes an obstruction to the free passage of particles from one side of it to the other. The radiant energy given up will represent in equivalent units the loss of kinetic energy whose forces originally sustained the particles in the

configuration. As the supporting forces are depleted, the shell of precipitated particles will exert an ever increasing force of compression and will eventually reduce the matter within it to the status of a solid, with its ultimate reacting unit, the atom, organized into such a system as to conserve its kinetic energies.

The continued precipitation of particles will leave, eventually, only an enclosing shell of the original configuration whose particles have kinetic energies sufficient to maintain them in it against the gravitational field. Thus, at this stage of development the celestial body will possess two distinct units of structure: a central globe, which has a solid surface and the attributes of a solid, and a radiating shell of free particles as in Fig. 1. The outer boundary of the shell will be its radiating surface and the inner boundary its surface of precipitation.

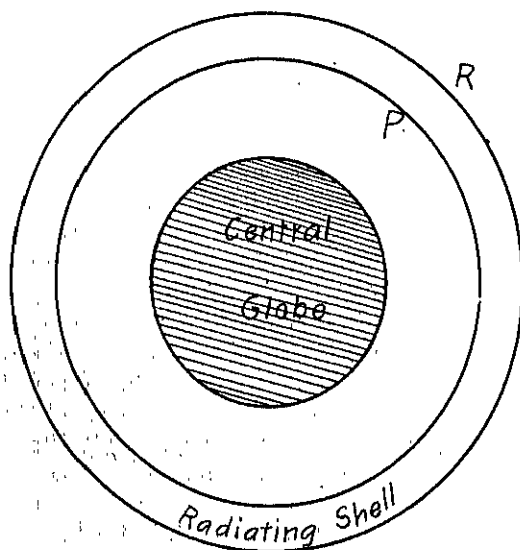


Fig. 1.— Units of Structure

The central globe will not acquire its successive strata without reactions which interrupt their orderly deposition. Elements and compounds laid down as solids may become liquids and gases again as changes occur in the temperature, pressure, and electrification to which they are subject. The problem imposed is that of tracing the reactions as new conditions develop.

2. Surface Eruptions

Temperature Gradient Effects.— As the space within the radiating shell is depleted of its particles through precipitation, a temperature gradient of ever increasing slope will develop within the central globe, since the clearing of the intervening space will make direct radiation more rapid. The deposition of one additional stratum will not change the temperature gradient of the configuration, for the increase in its diameter will be relatively small. In Fig. 2, let D represent the surface of the centroid, and A the outer surface of the additional precipitated stratum, which is the maximum that can be sustained without eruption under the conditions assumed.

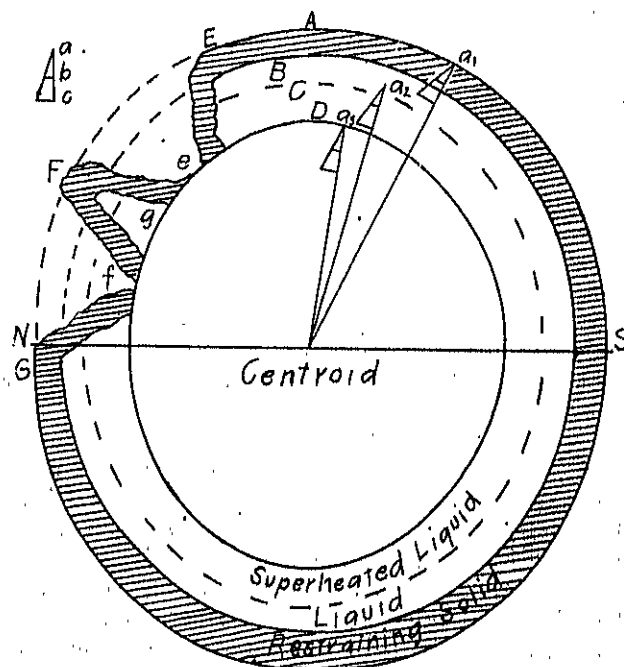


Fig. 2.— Conditions for Surface Eruptions

Suppose ordinates of a gradient triangle to represent temperatures corresponding to distances below the surface, as in Fig. 2, such that the ordinate, a ($= 0$), represents a degree of temperature below that of solidification, b a temperature of liquefaction, and c one of volatilization. The subscripts represent three supposed depths of surface strata. As the stratum increases in thickness through

precipitation, the gradient triangle is presumed to be successively situated so that its apex, a , is always in the outer surface, as at a_3 , a_2 , and a_1 . When b coincides with the surface, D , the matter in the overlying homeoid is still in a solid state but with a temperature of liquefaction at their common surface of separation. The matter in the homeoid, CD , will have become a superheated liquid when a attains the surface, A ; that in BC , a liquid between the boiling point and solidification. The solid part of the stratum, AB , remains of the same thickness while the depth, CD , of the superheated liquid continually increases. Due to this condition of forced equilibrium, the breaking point in the solid shell will be reached eventually, followed by an eruptive outflow of the superheated liquid from CD .

Localization of the Eruption.-- Because of the eruptive activities thus developed, the outer surface of the stratum, AB , may not have the uniform contour as represented by its bounding circle, A . Its contour might rather be as represented by the curve, $MeFFG$, at two points of which, as at e and f , it falls within the circumference of continuous solidity. In this case, the condition here described will develop in the intervening mound, g , whose top penetrates the circumference, A . When this condition is attained, the top of the mound will be subject to an upward pressure, as the enclosed, superheated liquid in its base is transformed into a gas. A crater commensurate in size with the forces thus developed will be formed as the overlying solid area is pushed upward and eventually removed. It follows that a mound of surface material may not attain a greater height than that at F without an eruption to cause its disintegration.

As Related to the Earth.-- The deductions with respect to the development of a liquefied stratum between the solid surface of the centroid and the outer solid homeoid is of practical significance in connection with the evolutionary processes through which the earth has passed. It may be assumed that the surface of the centroid, D , in the case of the earth, is concentric with that of sea-level. The effect of an underlying fluid stratum may then be considered as a function of sea-level elevation, only. It is evident from Fig. 2

that a low elevation will bring the outer homeoidal solid into contact with the centroid and give it relative stability as at e and f , while a high elevation above sea-level will yield an underlying fluid stratum and instability.

Where a continental area is afloat on a fluid stratum, and all its elements are subject at the same time to horizontal components of force acting in the same direction, it will move to such a geographical position as will give it renewed dynamical stability. The horizontal motion of segments of the outer homeoid has been an important factor in determining the present outline of continental areas. The phenomenon will be fully considered in the chapter on the earth.

Specific Implications.-- The surface, D , will be a boundary which marks a sharp distinction between the physical properties of the matter below it and that deposited above it. The presence of a temperature gradient, with concomitant eruptions, imposes the condition that the homeoid of matter within the surface, D , be a solid of sufficient tenacity to sustain the reaction of an eruption at a temperature which makes the overlying precipitate in contact with it a superheated liquid. It follows that, at whatever epoch of its development a celestial be, if it have surface eruptions two kinds of matter will be present, one of great density, high volatilization, and solidification temperatures, the other--superimposed above it--of relatively lower density and lower temperatures of volatilization and solidification.

This introductory discussion serves to present and visualize the problem of the surface eruption whose essential physical features are a solid base, D , an eruption tube, Gg , actual or potential, and a restraining cap, G , Fig. 3. Other factors than precipitation will appear as the cause of surface eruptions. In volcanoes, lateral and vertical compressions transform matter in the tube into a fluid and subject it to a potential transformation into an expanding gas. The phenomenon changes to an actual kinetic transformation, if the restraining force of the cap, G , is overcome.

Two other conditions may be considered as among those which result in the transformation of matter in the base of

the eruption tube into a superheated liquid. If matter of great density and high solidification temperature, in either a solid or a liquid state, were to descend from the outside with comparatively low speed and find lodgment in the base, *g*, the internal heat of the mass would yield the necessary transformation of the surrounding, more volatile matter into a compressed

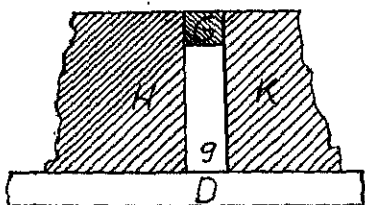


Fig. 3.— The Surface Eruption

gas or superheated liquid to produce an eruption. If a cool solid, moving with a high velocity, descended to the base, *g*, the kinetic energy of its velocity suddenly converted into heat would result in an eruption.

3. Sub-surface Eruptions

Eruptions not Localized.— With the temperature increasing from the surface toward the center, the matter within *D* will develop similarly into a solid outer shell, *DE*, which will enclose a homeoid of superheated liquid, *FG*, Fig. 4. The countour, *G*, may be regarded as the surface within which kinetic reactions between the component atoms have been brought to a state of continuous recurrence by the superimposed pressure to which the centroid is subject. In other words, *G* may be regarded as a solid surface throughout the discussion. Within this surface the kinetic and electrical energies of the centroid are attributes of the atoms themselves rather than of their motions and reactions with respect to each other.

The radio-active disintegration of the atom occurs at the surface, *G*, and proceeds as a function of the time. It is where the kinetic and electrical energies of the atoms of the centroid are released to become the source of the body's eruptive activity and of its luminosity. Outside the surface, *G*, the energy resident in the matter becomes that of the motions and electrifications of individual particles and atoms in mutual kinetic reaction.

As the energies of the fluid within the homeoid, *FG*, are thus renewed, the temperature gradient triangle will advance toward the outer surface of the restraining homeoid, *DE*. When its apex, *a*, touches the surface, *D*, a vent will be made through the restraining solid homeoid and a violent and long continuing type of eruption will be produced when an opening is once established. The superheated liquids within the homeoid, *FG*, will continue to be transformed into a gas and its particles to emerge with eruptive velocities until its state of forced equilibrium is largely removed. Throughout the discussion this type of activity is designated a sub-surface eruption.

Polar Caps.— In a rotating body, the greater gravity in the

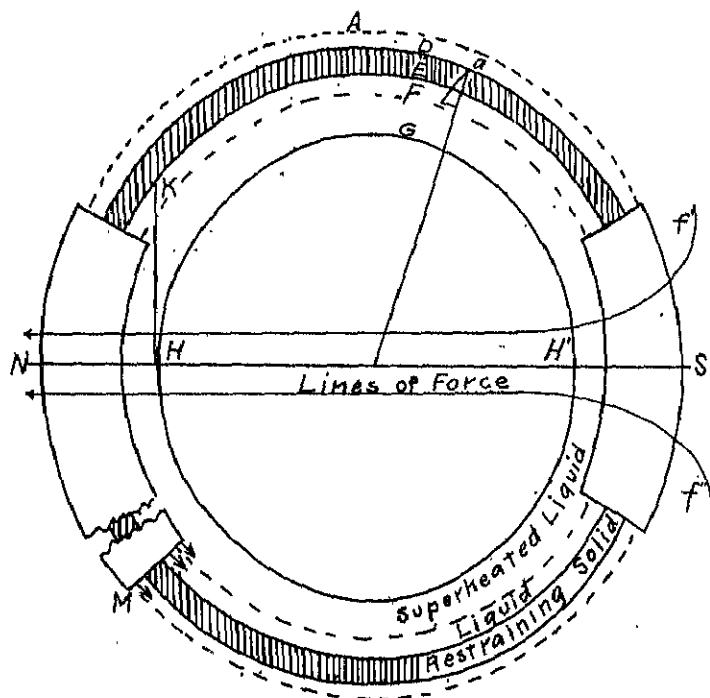


Fig. 4.— Conditions for a Sub-surface Eruption

zones about the poles will be equivalent to an increase in the textile strength of overlying strata in the polar regions. At each recurring sub-surface eruption in the equatorial zone there will be an immediate deposition of some of the ejected particles, together with those of the surface material carried up by the erupting column, of which the polar zones receive their quota. Platforms, or polar caps, will thus be erected about the poles, since their surface strata will be undisturbed by eruptions.

Electrification.*-- The reacting body will be subject to an intense magnetic field with lines of force, f' and f'' , Fig. 4, running from south to north through it, which will vary in intensity with its eruptive activity. Particles of the superheated liquid within EG, subject to this field, will distribute themselves according to their electrifications; negatively charged toward the north pole, positively charged toward the south pole, with a zone of neutral particles at the equator. When the particles attain the radiating shell through the body's eruptive activity, the restraining electrical fields will be absent, and the mutual attraction of oppositely charged particles will draw them together. Within the homeoid, EG, there will be electrical separation; in the radiating shell, electrical reunion of particles, with a consequent increment in the body's luminosity.

Relative Motions.-- A celestial body in the stage of development in which sub-surface eruptions occur continuously or in periodic time is in a state of mobility that makes the independent motions of its component units easily possible. Thus, the centroid within G will be completely separated from the solid overlying homeoid, DE, by the intervening liquids of EG. This condition makes a differential rotation rate between them inevitable, because the reaction of the eruption will impart to each, different rotational impulses.

The segment of a polar cap, M, will be supported by the liquids of EG and will be subject, correspondingly, to a mobility of motion along the surface. Lateral components of force due to the altered dynamic conditions of the centroid will react to move the segment along the surface. The

pressure thus exerted upon the solid surrounding matter will raise its temperature to the point of liquefaction and thus admit the segment to move to that point on the surface, where, with respect to the centroid, it will be again in dynamic equilibrium.

Through the body's eruptive activities the northern and southern hemispherical homeoids of DE may develop different rates of axial rotation. The implication of such a state is that the stratum in the zone affected has been raised to such a degree of temperature by the torsion of one hemisphere with respect to the other as to produce the plasticity requisite to such a differential motion.

4. Modifications Due to Rotation

Tangential Issue.-- The structural elements of a celestial body at the beginning of a sub-surface eruption whose reactions are affected by rotation are shown in Fig. 5. The axis, taken perpendicular

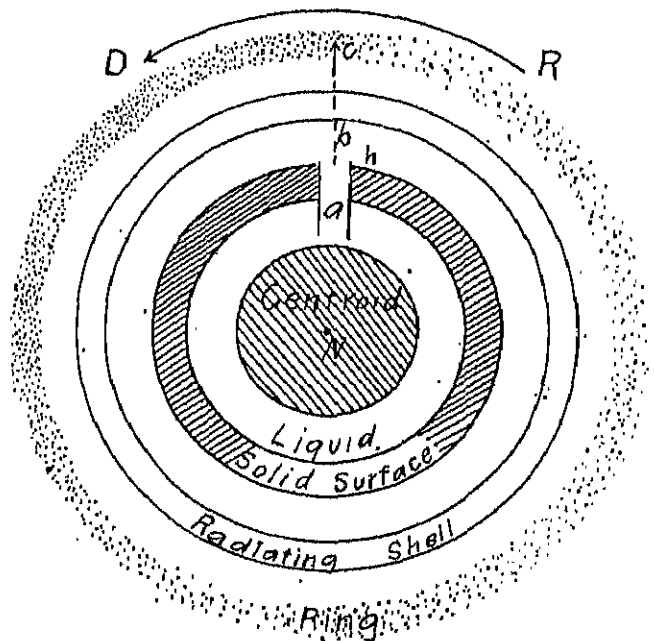


Fig. 5.— Beginning a Sub-surface Eruption

to the plane of the paper, appears as the point, N, with the implication that rotations are viewed from the north and,

*Discussion in Chapter II.

according to the arrow, RD, are counter-clockwise. The cross section may be regarded as representing any latitude plane parallel to the equator.

The eruption will begin with the development of a circular opening, a, through which superheated, electrified particles will be ejected. The course particles take in moving to the surface from depths below is designated an eruption tube. As their distances from the axis of rotation increase, deep-lying particles will lack the rotational momentum to sustain them at the same angular velocity as points on the surface. In consequence, the particles will reach the surface R-ward of the vent, as at h, and be constrained to move D-ward under the restraining surface, ah, and eventually to issue tangentially at a. From its initial radial direction, therefore, the issuing column of particles will move to that of tangency and be directed D-ward.

All the elements of structure due to the development of the sub-surface eruption are shown in Fig. 6. The centroid is represented by the circle of radius NG, the

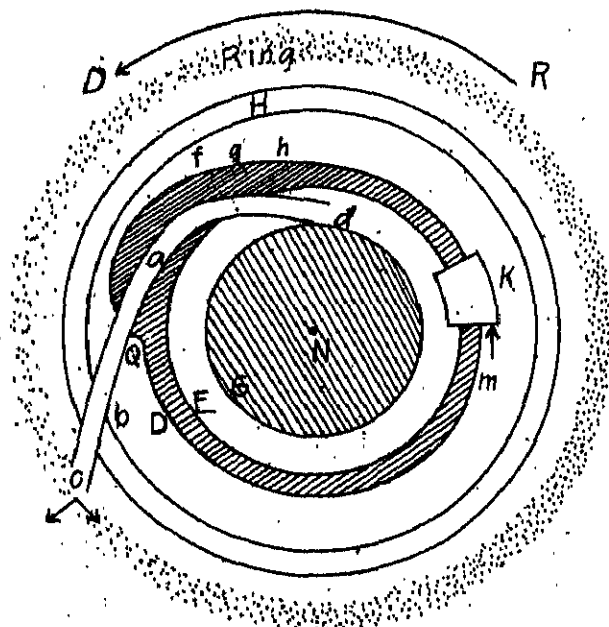


Fig. 6.— The Fully Developed Sub-surface
Eruption

homeoid within which kinetic reactions are renewed by EG, the restraining surface by DE, and the radiating shell by H. The

significance of the tangential issue of particles justifies the following mathematical consideration of it.

A Vector Proof.-- In a celestial body, let A, Fig. 7, be the aperture in the restraining surface concentric with a centroid whose axis of rotation is perpendicular to the plane of the paper, with the north pole at N. Suppose all elements of the structure to be rotating initially with the same angular velocity in the direction, RD. The answers to the two following questions will then elucidate the problem.

1. What path would the unit mass, \underline{m} , take in moving to the restraining surface, \underline{AB} , if it were projected radially toward the aperture and no forces acted on it other than those derived from the state of its rotation, and from its impulsive, radially directed force of projection?

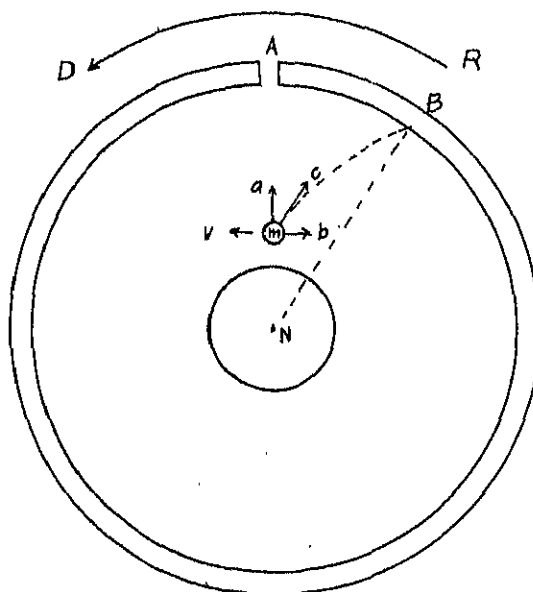


Fig. 7

With coördinate axes fixed with respect to the rotating surface, the unit mass would be subject to the condition implied in the equation,

$$wr = v = \text{a constant}, \quad (1)$$

where r is its distance from the axis of rotation, ω the angular velocity, and v its initial, linear, tangential velocity.
Differentiate both sides of

equation (1) with respect to the time, and it is found that,

$$-r \frac{dw}{dt} = w \frac{dr}{dt}. \quad (2)$$

The first term of equation (2) is a linear acceleration having a direction opposite to that of \underline{v} , as indicated by the negative sign before it. Since force is mass times the acceleration, $-r \frac{dw}{dt}$ may be regarded as a tangential force, \underline{mb} , acting on the unit mass, \underline{m} . The vector, \underline{ma} , represents the radially directed force, and \underline{mc} the resultant whose reaction determines the direction \underline{m} will move under the dynamic conditions postulated.

Successive values of the velocity term, $\frac{dr}{dt}$, could be derived by applying the laws of projectiles (falling bodies reversed) and, under assumed conditions with respect to the angular velocity, the curve for the motion of \underline{m} could be accurately determined. However, without going through this derivation, the course of its motion may be implied by putting equation (2) in the form,

$$- \frac{dw}{dr} = \frac{w}{r}. \quad (3)$$

From equation (3) it is evident that, as w assumes smaller values and r greater, the relative decrements in angular velocity with given increments of r , become less. If the final radial term of velocity, $\frac{dr}{dt}$ for example, becomes zero at \underline{B} , the problem with respect to the line, \underline{BN} , would be the reverse of determining the path of a projectile dropped from \underline{B} .

2. What would be the course pursued by the unit mass if it were subject to a high fluid pressure equal on all sides except that toward the aperture, where it is lower?

The initially assumed condition is that the unit mass, under high liquid pressure, is at rest with respect to the rotating fluid in which it exists. The coordinate axes are presumed to be fixed with respect to the outer surface.

The forces per unit area, due to the pressure of the expanding, surrounding fluid, acting on \underline{m} are represented by the vectors, $\underline{f_1}$, $\underline{f_2}$, $\underline{f_3}$, which, under the condition of equilibrium, are equal, as indicated in Fig. 8.

It is next assumed that the aperture formed at \underline{A} , Fig. 9, results in a decrease of the force, $\underline{f_1}$, on the side toward \underline{A} , in consequence of which the unit mass moves in reaction to the remaining forces to which it will then be subject.

The vector, $\underline{f_3}$, in this case, represents the residual force due to pressure upon \underline{m} , directed always toward the aperture, \underline{A} , and $\underline{f_4}$ the force, $-r \frac{dw}{dt}$, acting perpendicular to the radius at each point under consideration.

The forces which give motion to \underline{m} are represented at successive positions in Fig. 9. The vectors, $\underline{f_2}$, since they are equal and oppositely directed at all points, are shown only in the first figure of \underline{m} . The direction of motion of the particle is thus determined by the resultant, \underline{R} , of $\underline{f_3}$ and $\underline{f_4}$ which, it should be noted, is not at any point toward the aperture but toward the section, \underline{AB} , R-ward of it.

As the distance from the center increases, the forces, $\underline{f_3}$, have a continually increasing forward inclination with respect to the radius, and under this condition impart to \underline{m} a high tangential component of velocity. As all particles between r_1 and r_A will be similarly affected, it follows that the erupting column of a celestial body in sub-surface eruption issues at a low D-ward angle of inclination to the tangent plane at the point of issue, as angle \underline{VAT} .

Observational evidence indicates that the liquid homeoid from which the particles composing the erupting column may be drawn, is relatively shallow. Hence, if the surface of the centroid were expanded to \underline{G} , Fig. 9, it would more nearly simulate actual relations than it does in its present position at \underline{E} . In this case the eruption tube would be confined to the homeoid, \underline{BQ} , and for this reason would approach parallelism with the surface, as its particles were driven by fluid pressure toward the aperture, \underline{A} . Under these conditions, the erupting column would emerge tangent to the surface at the point of issue.

The observational data indicating that the liquid homeoid, \underline{BQ} , is relatively shallow are: the short duration of maximum light in novae, and the recurrence of minima in the sun-spot cycle and in the luminosities of certain variable stars. These and similar phenomena may be accepted

as evidence that the respective sources of eruptive particles are depleted to the extent that eruptions cease or are of decreased intensity. They may be taken to indicate, also, that the matter composing the centroid of a celestial body is not in a state of immediate availability as material for the eruption.

To illustrate the effect of rotation when a particle is brought to the surface from depths below, suppose a celestial body of 100,000 miles radius to be rotating on its axis in a period equal to that of the sun--26 days. The linear velocity of a point on the surface would be $(\frac{2\pi}{26 \times 24} \times 100,000)$ 1,000 miles per hour.

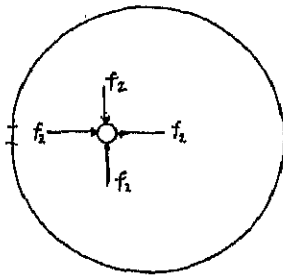


Fig. 8

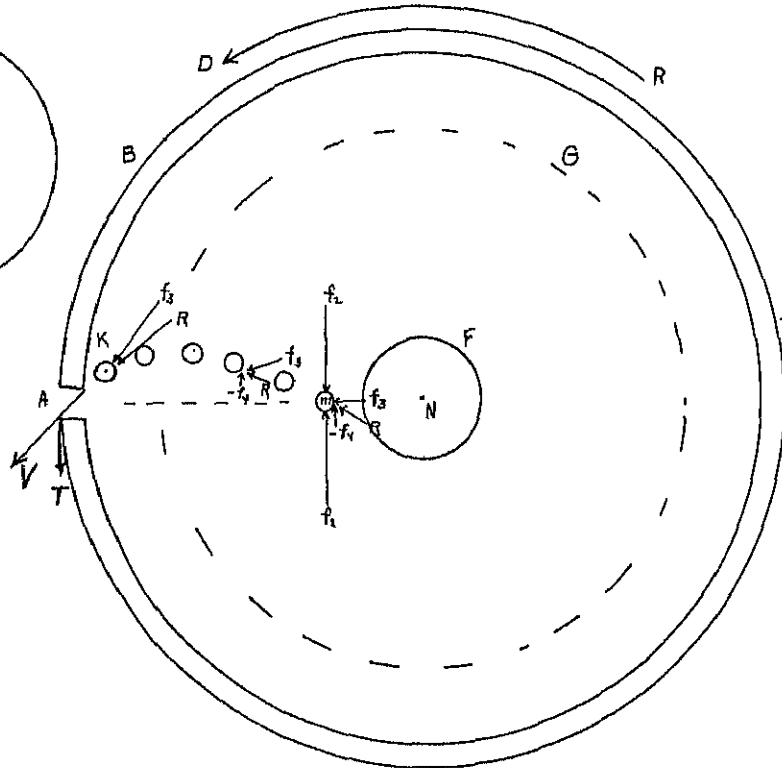


Fig. 9

A scalar representation of the velocity at the point of issue may be made as in the following equation,

$$V = \int_{t_1}^{t_A} F(f_3 - f_4 \cos \theta) dt \quad (4)$$

which may be stated thus: The velocity at issue is equal to a function of $(f_3 - f_4 \cos \theta)$ integrated with respect to the time along the path of \underline{m} from its initial point, r_1 at time, t_1 to the point of issue, r_A at the time, t_A . The term, $-f_4 \cos \theta$, is the projection of $-f_4$ on f_3 . At r_1 , the angle, θ , is 90° , at r_A it approaches the value, zero.

A particle transferred to the surface from a depth of 5,000 miles would have a surface velocity of 950 miles per hour. The difference, 50 miles, is the rate per hour at which the transferred particle would move R-ward, that is retrograde, along the surface if the condition be fulfilled with regard to it that

$$wr = v = \text{a constant.}$$

In celestial bodies where matter is transferred with high velocities and in great quantity from depths below, friction will have little immediate effect in modifying the law implied in the above equation,

or in changing phenomena arising from the transfer.

5. Restrictions of Sub-surface Eruptions

With Respect to Latitude.-- A result which follows from the differential angular velocity between the surface vent and particles coming from depths below, is that eruptive activities will be confined, in considerable measure, to the latitude circle in which the eruption occurs. Deeplying particles, because of their lesser angular velocities, will always rise to the surface R-ward of the vent as at h, Fig. 6, and be constrained to move D-ward in the latitude plane of its occurrence, thus establishing its eruptive activity in the plane of the given latitude circle.

A Moving Point of Eruption.-- The stream of particles emerging at Q, Fig. 6, will have a disintegrating effect upon the solid restraining homeoid in the section, EQ, such that the point of emergence of the erupting column will move gradually D-ward, thus making its period of rotation about the axis, N, shorter than that of the body's period of axial rotation. The point of eruption will remain stationary for a long period of time if the section, QD, is of such structure as to offer a high resistance to the disintegrating effects of the erupting column, but it will advance if the section undergoes rapid disintegration.

Since eruptive activities begin in middle latitudes and move toward the equator, a point of eruption will move correspondingly, thus establishing a longitudinal zone of eruptions in approximate coincidence with a meridian. The deviation of the zone of eruptions from exact coincidence with a meridian will be due to a variation in surface conditions as the zone moves in longitude. Thus the point of eruption will be subject to restrictions as to position, both in latitude and longitude.

A Column of Special Structure.-- It is evident that the stream of particles issuing from ad, Fig. 6, will have an organized liquid from which the force of the eruption is derived will flow, necessarily, through an aperture in the solid surface and through the surface liquids above it. The explosive reaction of the superheated

liquid will be expended, in no small measure, in imparting velocities to the cooler surrounding liquids and to disintegrated surface materials as they become incorporated as a part of the outflowing stream. The electrified particles will form the core of the rising column which will acquire a rotary motion as it flows through the tube, ad. When the column leaves the centroid, therefore, it will consist of a rotating cylinder of cool particles, at whose center there will be a more rapidly rotating core of superheated particles moving outward with a higher velocity than its enclosing sheath.

An Encircling Ring.-- The particles of the erupting column projected tangentially will impart tangential impulses to the radiating shell as they penetrate and become incorporated as a part of it. For the newly acquired particles, the outer surface of the radiating shell is an equipotential surface with respect to which they distribute themselves in latitude according to their respective angular momenta; those of greatest velocity at the equator, those of less velocity in higher latitudes. To the dynamical forces reacting to move newly acquired particles toward the equator, will be added the electrical attractions between aggregates of particles in the two hemispheres which carry opposite charges of electricity.

In this manner individual velocities will become so great, eventually, that particles at the equator will be sustained against the gravitational field, with no transverse kinetic impacts among them. A new unit of structure will thus develop in the celestial body; namely, a ring of particles revolving about it in the plane of the equator.

The ring will expand in diameter as subsequent eruptions increase its rotational moment. Its component particles, in consequence, will describe orbits in a field of continually lower gravitational potential. The force of attraction between the particles of the ring in this expanded state will then dominate their motions, and under its reaction they will be drawn together to form a satellite. Some of the erupted particles may attain parabolic velocities and be lost to the system.

6. The Disintegration of Polar Platforms

A Figure of Instability.-- The undisturbed deposition of matter in the polar zones, together with its continuous loss of radiant energy, will result in the formation of solid platforms of superimposed strata whose immobility will increase the polar diameter beyond what it would be otherwise for dynamic equilibrium. If, because of increasing solidity, the body lacks the resilience to reattain a figure in dynamic equilibrium continuously, then the matter in the polar zones will be subject to tangential components of force directed toward the equator.

In the mobile state already considered, the angular momentum imparted through the agency of the erupting particles to the radiating shell and encircling ring, will be derived from the rotating centroid within Q , Fig. 6, through the impulsive reaction of the eruption. The angular velocity of the centroid will undergo a sudden diminution at each eruption which will be imparted to the polar caps or other portions of the solid, inclosing surface, DE , very gradually because of the intervening liquid, EG . Because of the horizontal forces to which they are subject, the solid polar caps of stratified material will break up into sections, large or small, and these will move along meridians toward the equator.

Motion toward the Equator.-- The horizontal components of force which react to move severed segments toward the equator will be due to the excess of their retained angular velocities of rotation over that of the underlying centroid and to the development of a figure of dynamic instability. As severed segments move along meridians toward the equator, their angular rotational velocities will decrease as a result of their attaining greater distances from the axis of rotation as they move into lower latitudes. When they reach the latitude circle at which the horizontal forces acting on them become zero, the segments will again be in dynamic equilibrium above the centroid. At each succeeding sub-surface eruption new horizontal components of force will develop, under whose reaction the polar cap segments will again move toward the equator along their respective meridians. Severed segments

from the two polar caps will meet, eventually, at the equator, as at Q , Fig. 10, where they may telescope each other or turn their edges up into high elevations.

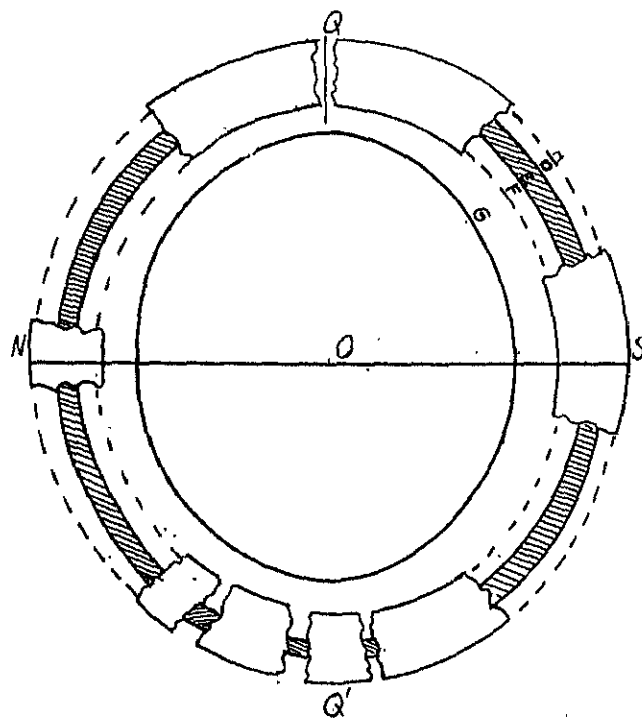


Fig. 10.-- The Disintegration and Movement of Polar Caps

7. Body Vibrations

Reattainment of Stability.-- The conditions which inaugurate a series of sub-surface eruptions are those of maximum internal instability. Once an eruption begins, the forces whose reaction will restore the body to a state of normal equilibrium will rise speedily to a maximum and decrease thereafter throughout the period of readjustment. In the curves, AE and $A'E'$, Fig. 11, the ordinates represent the relative magnitudes of the forces reacting throughout the period; the abscissae, both the changes in latitude and those in the time interval from the beginning of the activity.

Eruptions will begin at a latitude circle below each of the polar caps, as at A and A' , and rise speedily to a maximum at B and B' . Since the reaction of an eruption takes place in a plane parallel to the equator, the latitude overlying

the greatest depth of superheated liquid, measured in the plane, as HK, Fig. 4, will be where the homeoidal shell, EG, intersects the axis of rotation.

equator in successive order. Thus, eruptions which began in higher latitudes will occur successively in lower latitudes as the period progresses.

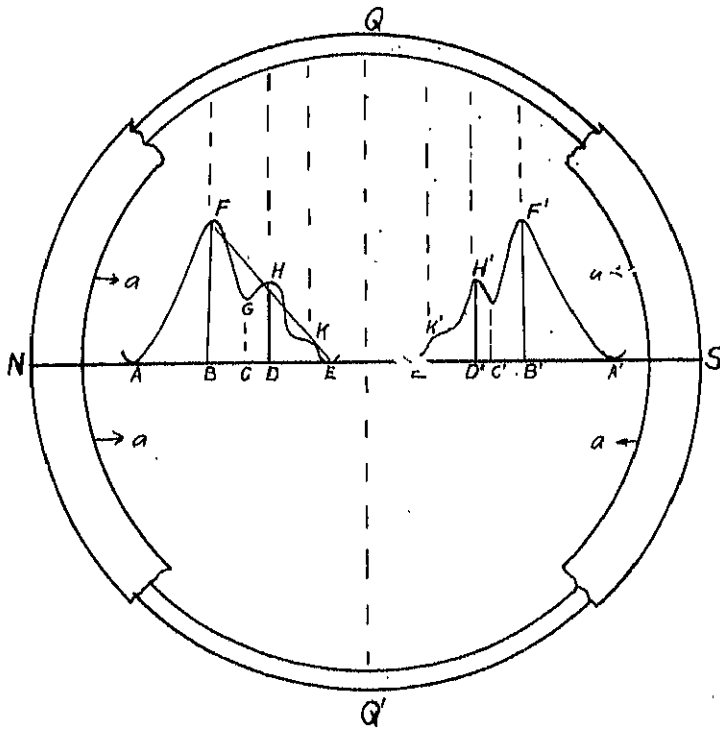


Fig. 11.-- Forces Modified by Homeoidal Vibrations

Variation of Forces.-- The maximum potential due to a forced equilibrium having been attained and eruptions begun--following a period of quiescence--the polar caps will move toward each other, inaugurating a series of body vibrations whose first condensation, indicated by the arrows, a, Fig. 11, will increase the forces due alone to eruption. The straight line, FE, would represent best the decline of the eruptive forces through the period, but as modified by the reaction of the vibrating body the curve, AFGHK, becomes their true representation. When the eruptive forces in the latitude circle, A and A', have been expended, eruptions will be inaugurated in latitude circles nearer the

Recapitulation

These considerations lead to the conclusion that the essential units of structure in a radiating celestial body are: (1), a centroid which may be regarded as a solid; (2), a surrounding homeoid where liquefaction takes place; (3), an outer surface of sufficient tenacity to impose a state of forced equilibrium, which may be regarded as a solid; (4), a radiating shell which overlies an atmosphere in contact with the surface; and (5), polar caps of considerable mass, at the extremities of the axis of rotation.

The centroid is a storehouse of kinetic and electrical energy which eventually is transformed into radiant energy at the outer surface of the radiating shell. It is presumed to possess the attributes of a solid because the motions of its ultimate unit, the atom, however great its internal kinetic and electrical energies, have been restricted to

those characteristics of solids by the high pressure and intense electrical field to which it is subject.

The disintegration and ionization of atoms derived from the centroid take place in the homeoid which encloses it. Negatively and positively charged particles are drawn into alternate laminae whose planes are perpendicular to the axis of rotation. This homeoid is the chamber within which particles from disintegrated atoms undergo a preparation which renders them especially fitted to give up their internal kinetic and electrical energies as radiant energy when they have been transferred to the radiating shell through eruption.

CHAPTER II

THE SUN

1. Sun-spots

The Photosphere.-- The visible part of the sun is the outer surface of its radiating shell. The high luminosity of the shell is due to its being replenished continuously by electrified particles erupted through an underlying solid, or plastic, surface of sufficient tenacity to produce a condition of forced equilibrium.

Sun-spots are aggregates of matter above the radiating shell which appear dark upon the solar surface because of their low intrinsic luminosities. In particular, also, those points are spots at which a flow of particles through the radiating shell--outward, downward, or both--occur. Where aggregates of matter are projected tangentially through the radiating shell by sub-surface eruptions they possess a definite structure which consists of a cylindrical configuration having a core of electrified particles and an enclosing sheath of cooler surface matter. The arc of the erupting column which rises to visibility above the sun's radiating shell, in addition to appearing dark upon the photospheric background, exhibits physical properties and undergoes characteristic transformations which confirm the implications of this analysis.

As the erupting column penetrates the radiating shell and produces a spot in its outward motion, a second spot in advance of it will mark the column's downward penetration of the radiating shell. The condition is illustrated in Fig. 12, where abc represents the erupting column which penetrates the radiating shell, A, in the spots, b and c, and between them rises above the photosphere.

Zeeman Effects in Sun-spots.--

Charged particles from the interior homeoid, which compose the core of the erupting column, will establish a magnetic field in the space through which the core moves, whose lines of force will be perpendicular to

its direction of motion as indicated by the arrows between b and c, Fig. 12. If spectroscopic observations of a spot be made when it is at the center of the sun's disk, as from P, the lines in its spectrum will be doubled and circularly polarized. This effect follows when light is observed through a magnetic field whose lines of force are directed in the line of sight, as the arrows between b and c are with respect to P.

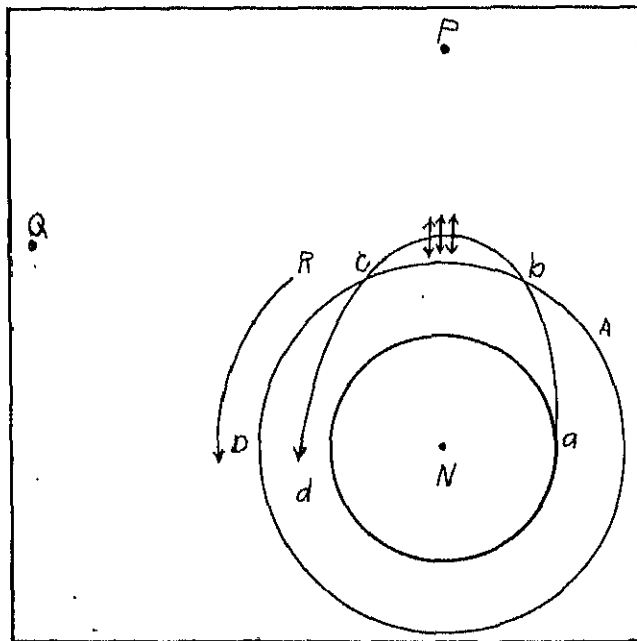
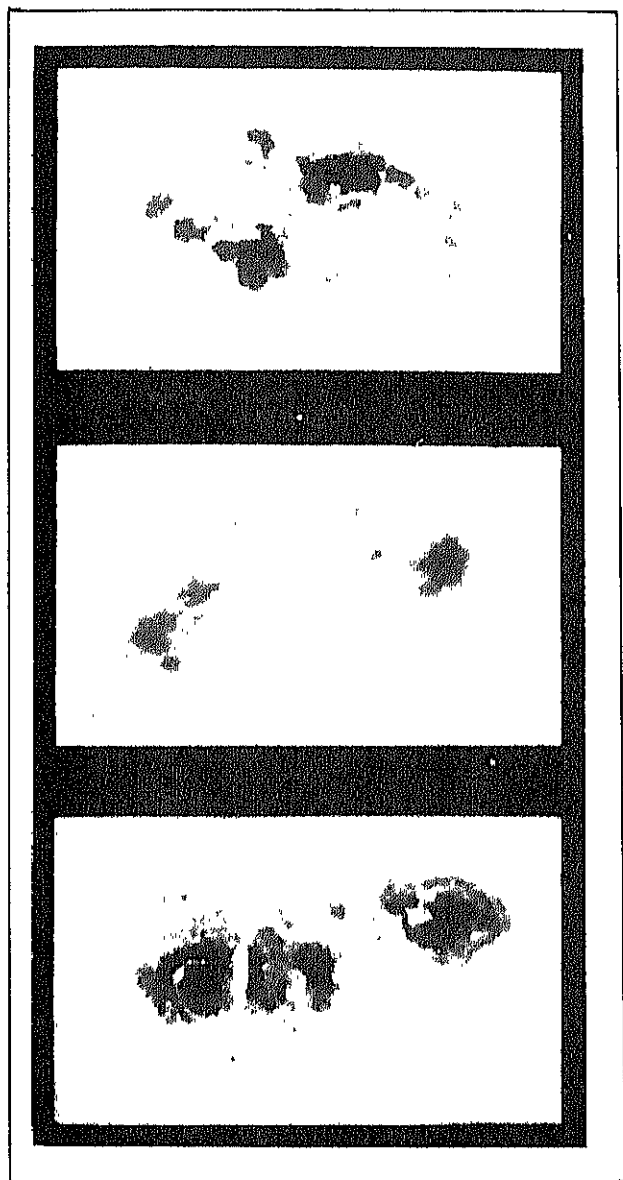


Fig. 12.-- The Course of an Erupting Column

If an observation of the spot be made when it is near the sun's limb, as from Q, its spectrum lines will be triple and plane polarized, a result which follows from observing light that has passed through a magnetic field whose lines of force are at right angles to the line of sight, as the arrows are between b and c with respect to Q. The Zeeman effects are incontestable proofs of the presence of



Mount Wilson

Fig. 13.— Double Sun-spot Development

A.— Aug. 19, 1916

B.— Feb. 8, 1917

C.— June 17, 1907

A

B

C

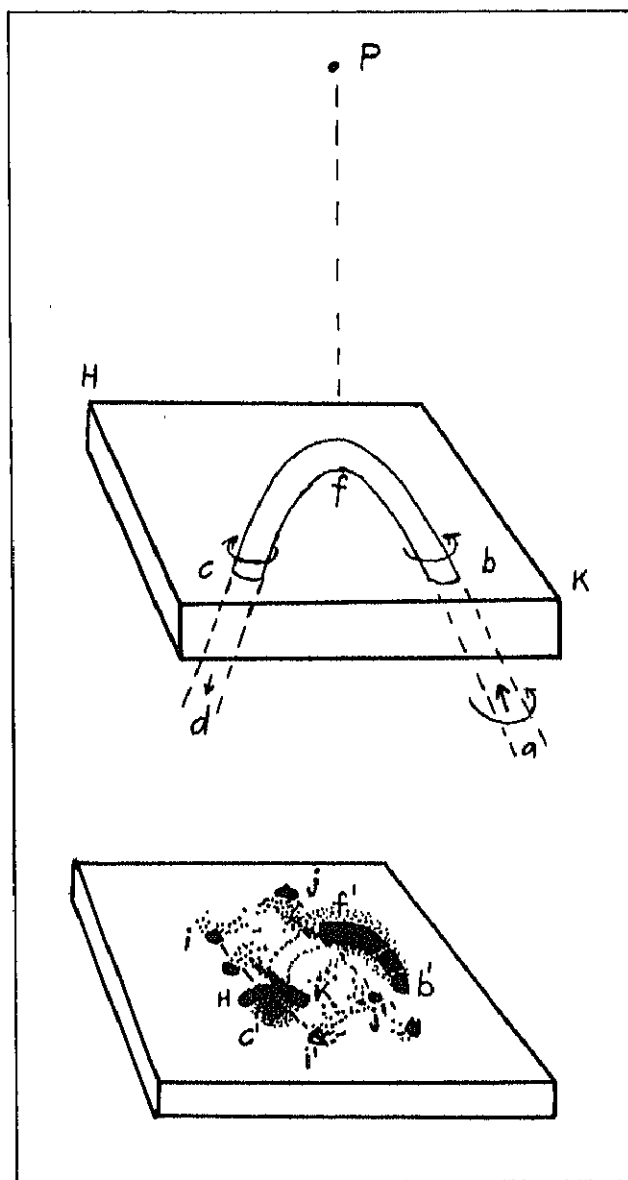


Fig. 13:D.— Oppositely Directed Vortical Motions and Polarities in Sunspots. Cylindrical Disruption

streams of electrified particles moving in direction and manner in accord with the deductions of the hypothesis respecting them.

The effect of a convection current on a magnetic needle was investigated by Rowland. A gilded ebonite disc, maintained at a high potential, was rotated beneath a sensitive magnetic needle suspended parallel to its circumference. It was found that the needle was deflected to the right or left according to the direction of motion of the disc and to the sign of the charge on it. Thus, similar charges moving in opposite directions or opposite charges moving in the same direction produce opposite polarities. To an observer at P, the moving stream of particles, abc, would simulate the condition at b and c of two streams of similarly charged particles moving in opposite directions. Thus the opposite electrical polarities observed in pairs of sun-spots are an anticipated result of this relationship.

The Bi-polar Sun-spot.-- The erupting column will inevitably acquire a motion of rotation about its longitudinal axis and in rising to the surface will superinduce characteristic cyclonic motions in the medium through which it moves. The rotary motion thus imparted to the radiating shell will be observable in the spots, b and c, Fig. 13:D*, as oppositely directed vortical motions in the surrounding medium. The stream of particles spanning the space between the spots, may appear as luminous matter between them. The stream of charged particles will be moving toward the observer, P, through b and away from him through c.

As the forces of the eruption develop, the outward velocity of the column will increase, and the stream rise higher above the photosphere. The arc, bc, will become longer and increase in height above the surface. The preceding spot, c, the point of the column's descent to the photospheric surface in the direction of the sun's rotation as the forces of the eruption increase, and backward as they decrease. The following spot will disappear first, as the stream of particles ceases to flow; the one preceding will persist until all the stream particles in the arc, bc, have moved downward through c. Although

the preceding spot moves forward during the period that the eruptive forces are increasing, yet its position at the cessation of the activity will be in the longitude, approximately, of the original disturbance. The arc, bc, will grow shorter as the velocities of the particles traversing it decrease.

Deviations from this type of sun-spot development may be expected as a result of variations in the forces of eruption and in those which maintain the structure of the outflowing stream. The erupting column, for example, may undergo disintegration above the photosphere or return through the same aperture as that by which it flowed out; or non-luminous particles congregating above the photosphere may flow downward through it. Mount Wilson observers find that the double-spot type of development occurs twice as frequently as the single-spot type.

Photographs showing the vortical motions, oppositely directed, in pairs of spots have been taken at Yerkes, Mount Wilson, and other observatories, and the magnetic conditions deduced for sun-spots are confirmed by the observations of George E. Hale and his colleagues at Mount Wilson.

Eruptive Prominences.-- As the erupting column emerges into the region of low pressure and changed magnetic potential above the photosphere, it expands with such explosive violence as to scatter the disrupted fragments of its outer sheath to the surrounding space. Manifestations of this reaction are apparent in the appearance of eruptive prominences associated with sun-spots as the core of electrified particles is freed of its enclosing sheath.

The condition of this sudden expansion is represented in the arc, b' f' c', which is drawn as the counterpart of the configuration in the 'young' spot, A, Fig. 13. In a day's interval the erupting column rises to visibility, passes upward through the photospheric surface, undergoes disruptive expansion in the sections adjoining f', and in a state of disorganization, attains a downward penetration of the photosphere at c', to which the materials of the disruption are drawn by vortical approach. The sharp discontinuities presented by a spot group, as in the arc,

* "D".-- Drawn to depict the lineaments of an illustrative drawing or photograph having the same figure number.

$b' f'$, indicate that its materials are in a transitional stage, from a condition in which they maintained a characteristic structure under the reaction of definite forces to that in which such a structure is dynamically impossible under the altered conditions.

Reconstructing a Spot.— To rebuild the spot into the column it was before disruption, reorient HK through 90° so that H coincides with c' , and K with f' ; move ij and $i'j'$ to coincidence with the column, $c'f'$, and the reconstruction is complete.

The configurative evidence of the nature of the disruption is obliterated, in a measure, by the proper motions and volatilizations of individual spotlets. Nevertheless, the older spots retain characteristic features which indicate the nature of the activity in their formation. Thus in B , Fig. 13, ij and $i'j'$ mark the boundaries of a cylindrical disruption, while the region between may be regarded as that of the arc, f' , traversed by the erupting column.

It is to be anticipated that the cool particles of the first disruptive flow will be followed by those of greater radiation potentials. If the luminosity of the erupting column becomes similar to that of the photosphere, an invisible spot, detectable only by its magnetic effects, would be produced.

2. The Sun's Magnetic Field

Motion of Electrified Stream.— The outward and downward penetrations of the radiating shell, as at b and c , Fig. 12, mark but the beginning of the stream's activity. Its particles will move onward in the direction, d , in a complete encircling belt of activity in the latitude circle of the eruption. If the brilliancy of the photosphere were reduced and made more transparent, the manifestations which now appear only in connection with spots would be observable in a complete encircling belt.

The magnetic field which accompanies an erupting stream will be a feature of its activity not only through the arc, bfc , Fig. 12, but thereafter until its forces are completely spent. Its relation to the centroid is represented in meridian cross

section in Fig. 15, where NS is the axis of rotation and r' and r'' are cross sections in their latitude circles, of streams of erupted particles. As considered from N , a stream of charged particles

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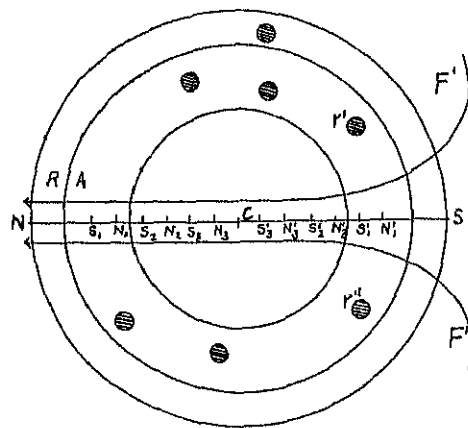
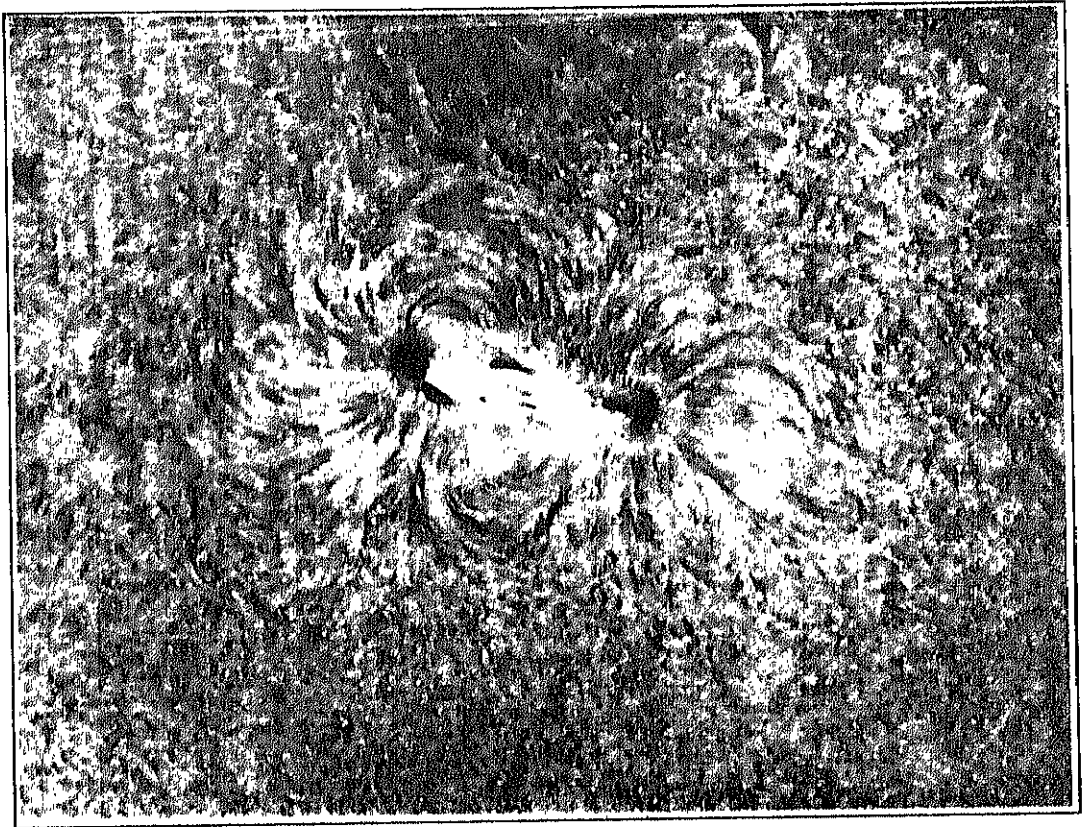


Fig. 15.-- The Sun's Magnetic Field

flows counterclockwise through r' and r'' producing an electrical field whose lines of force, F' and F'' , penetrate the centroid from south to north. Every erupting stream will carry electrostatic charges and produce a field in proportion to the magnitude of its flow. It follows that the total magnetic field to which the centroid will be subject at a given time will be in direct proportion to the sun's eruptive activity.

The Sun's Magnetic Axis.— Subject to the fields of force of its erupting columns, through a long interval of time, the atomic elements of the centroid of the sun have become permanently magnetized with their magnetic axes approximately parallel to the axis of rotation. In summation their magnetizations constitute the magnetization of the sun. Changes of figure in the body of the sun may result in a shift of its axis of rotation, such that the two axes no longer coincide. The evidence of a change of figure is found in the deviation of a body's magnetic axis from



Mount Wilson

Fig. 14.-- Bi-polar Sun-spot Group

coincidence with its axis of rotation. Mount Wilson observers find that the sun has a magnetic field whose north pole is four degrees from the pole of rotation.

In the sub-surface homeoid of the sun, if ionized particles are separated into laminae perpendicular to the axis of rotation so as to be alternately positive and negative, the internal magnetization of the sun will be such as to yield consequent poles, as indicated by the letters, N_1 -- S'_1 , Fig. 15. In that case its observed will be its residual rather than its total magnetization.

An eruption in the zone, S_1 , creates a magnetic field whose effect is equivalent to decreasing the magnetic force holding particles to the N-pole laminae. An eruption is thereby superinduced in the lamina, N'_1 , since it is under dynamic conditions most favorable to eruption. In turn, the eruption in the lamina, N'_1 , decreases the electrical forces holding particles to laminae of the consequent poles, and results in an eruption in the zone, S_2 . The process is repeated until the equator is attained.

Thus all the S laminae of the northern hemisphere and the N of the southern are relieved, in order, of their eruptive tensions. In the cycle which follows, the activity is repeated, with the N laminae in eruption in the northern hemisphere and the S laminae in the southern. These implications of successive opposite polarities, alternating in 11-year cycles, are confirmed by the observations of polarities in sun-spots as recorded at the Mount Wilson Observatory.

The Earth's Magnetic Variation.-- In addition to making the sun a magnet, its erupting streams produce a magnetic field in the surrounding space, whose strength is directly proportional to the sun's eruptive activity and whose variation is represented by the sun-spot curve. Since the earth is in this magnetic field and subject to its changes of potential, it will exhibit essentially the cycles of change in its magnetism that are coincident with those of the sun-spot curve.

The Sun's Radiant Energy.-- As the cohesive forces of the stream, abcd, Fig. 12, grow less effective in maintaining its structure, the charged particles of its core escape from their sheath and mingle by kinetic reaction with those of

the radiating shell. In this way the static charges carried by the particles become oscillating electric charges of the radiating shell and constitute a renewal of the sun's radiant energy.

The earliest manifestation of the mingling of particles from the disintegrating eruptive column with those of the photosphere will be that of intense radiation, since their electrostatic energy will then be greatest. The phenomenon incident to this activity is the appearance of faculae on the sun's surface. Evidence in confirmation of this deduction is found in the close association of faculae with sun-spots, in their activity in a complete latitude circle, as in Fig. 17, in their variation in number and intensity with the sun-spot cycle, and in the manner of their formation and disintegration. In faculae the photosphere may be observed in the actual process of renewing the sources of its radiant energy from particles recently derived through sub-surface eruption.

3. Homeoidal Vibrations

Force Curves.-- The sun-spot number curve, from the manner of its derivation, represents the relative quantities of matter projected into the photosphere during a sun-spot period. These will be in direct proportion to the forces required to accomplish their transposition. It follows that the ordinates of the sun-spot curve may be regarded as representing the relative magnitudes of the sun's forces of eruption throughout the period, as f, Fig. 16:D. The deviation of the sun-spot curve from uniformity is to be regarded as indicating the modifications which the forces undergo through the body vibrations of the sun throughout a period of eruption.

A more exact representation of the sun's eruptive activity is contained in the latitude chart of sun-spots by E. W. Maunder as published in Monthly Notices, Vol. LXVI, Plate 16, of which one cycle is represented in Fig. 16. The details of spot activity shown in Maunder's chart are subject, on the basis of these deductions, to the interpretation represented in Fig. 16:D.

Maunder's Chart.-- The lines in the chart, which represent individual spot activities, cover the latitudes of the sun

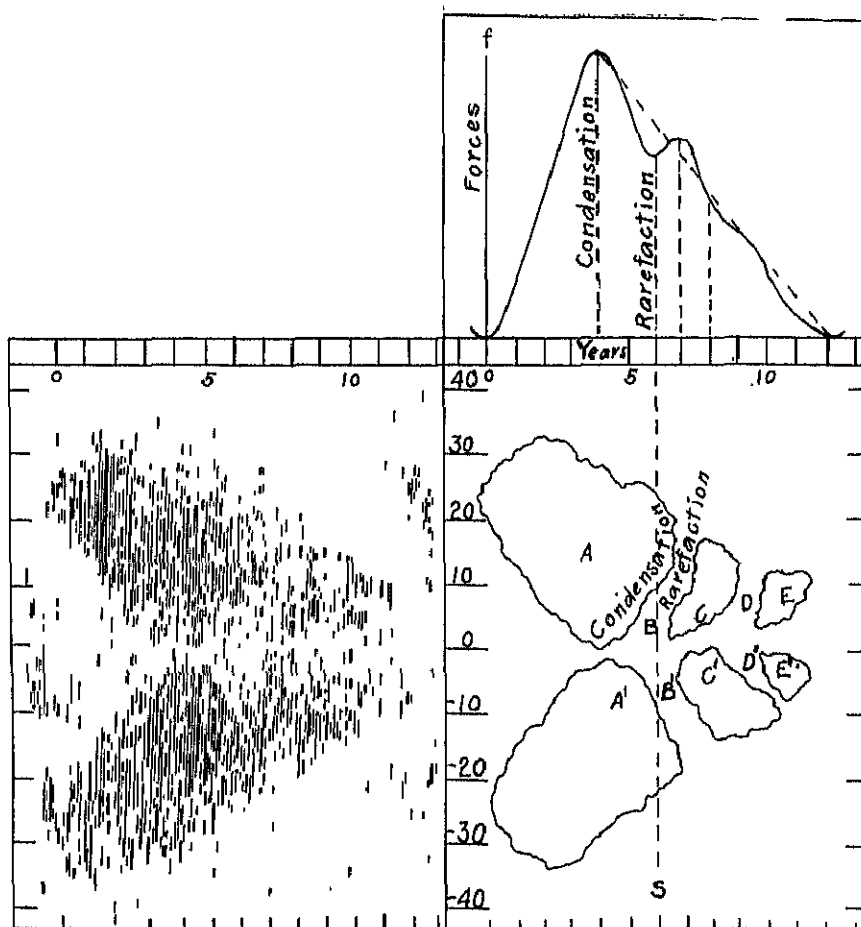


Fig. 16.--- Spot Distribution

Fig. 16:D.--- Sun-spot Curve

in which spots were found at each synodic rotation. The lines may be regarded as representing the magnitudes of the sun's eruptive forces and the time and latitude of their individual occurrence. Areas where the lines are long and close together are to be regarded as indicating that the underlying surface homeoid in their respective latitude circles was subject to a state of condensation; where the lines are short and infrequent, to a rarefaction.

With this interpretation, Fig. 16 represents the nature and course of the wave motions in the celestial body, the sun, in reaction to sub-surface eruptions. At the inception of a sun-spot period eruptions begin in higher latitudes and inaugurate wave motions in both hemispheres which attain maximum condensation where they meet at the equator. A wave in condensation moves toward higher latitudes, advancing with the time, as in A and A', fol-

lowed in successive order by rarefaction and condensation as indicated at B, C, D, and E.

It is significant that the rarefaction, B, in the northern hemisphere is more distinctly indicated in Maunder's chart than that in the southern hemisphere, B'; and similarly with respect to succeeding rarefactions coincident in time. The implication is that the southern hemispherical surface shell is the more massive, and that the northern in consequence, undergoes the greater and more complete vibration with respect to it.

The reason for this condition is found in the electrical separation in progress within the interior homeoid of superheated liquids underlying the outer surface shell. The lighter, negatively charged electrons of the ionized atoms will be drawn to the northern hemisphere in the sun's

magnetic field, while the heavier protons of equal positive charge will be attracted to the southern. Eruptive activities, therefore, will result in a greater mass reaction south of the equator than north of it.

A defect of the sun-spot number curve in depicting correctly the vibrations of the reacting body will be apparent from an examination of Fig. 16:D. The line, S, for example, with respect to which the corresponding ordinate of the curve is determined, crosses both condensation, A, and rarefaction, B, and thus cannot represent as distinct entities these two reactions. In reality the sun-spot curve gives, relatively, the dominant activity of the sun's vibration throughout a period, while Maunder's chart depicts its activities in detail.

Increasing Equatorial Velocity.--- Every sub-surface eruption will impart a

ential component of acceleration to the radiating shell thus increasing the velocity of surface particles, those in particular at the sun's equator. With regard to deduction, the following observational data is significant: "Measures by St. John for a period of several years indicate a gradual increase in the linear velocity of the sun's rotation at the equator, the present value being nearly 2.00 km/sec. No apparent change is not associated with the 11.2-year sun-spot cycle."--Mount Wilson Observatory Report, 1933.

Summary with Respect to the Sun

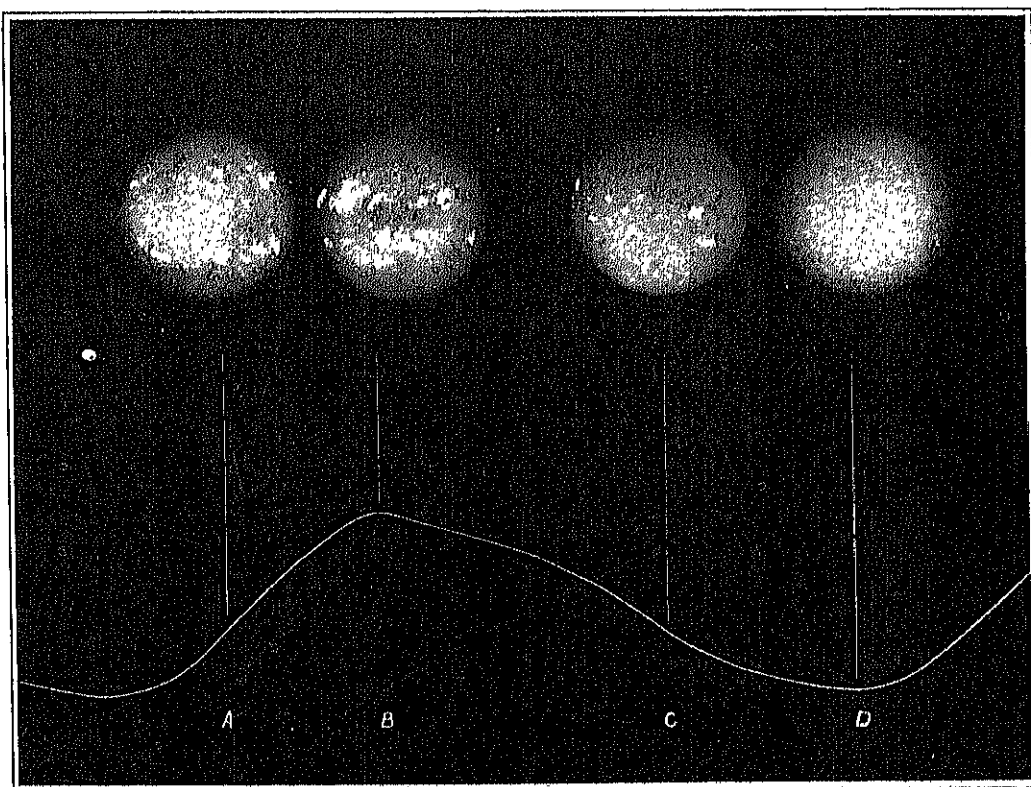
With regard to the deductions thus considered, the Hypothesis of Eruptions applied to the sun may be stated in simple terms. The surface homeoid of the sun, DE, Fig. 4, is composed of particles solely non-resonant to the electromagnetic field in which it exists, as to be a restraining medium to the free passage of particles from one side of it to the other. Due to the continuous ionization and radioactive disintegration of the atoms, taking place within the underlying liquid homeoid, FG, eruptive conditions are repeated at approximately equal periods of time.

Since the eruptive forces react in lines parallel to the plane of the equator, the latitude circles at which eruptions will begin after a period of quiescence, will be those at the northern and southern boundaries of their respective zones of activity. Here the greatest

depth, HK, Fig. 4, of the underlying liquid homeoid, in laminae parallel to the equator, will be found.

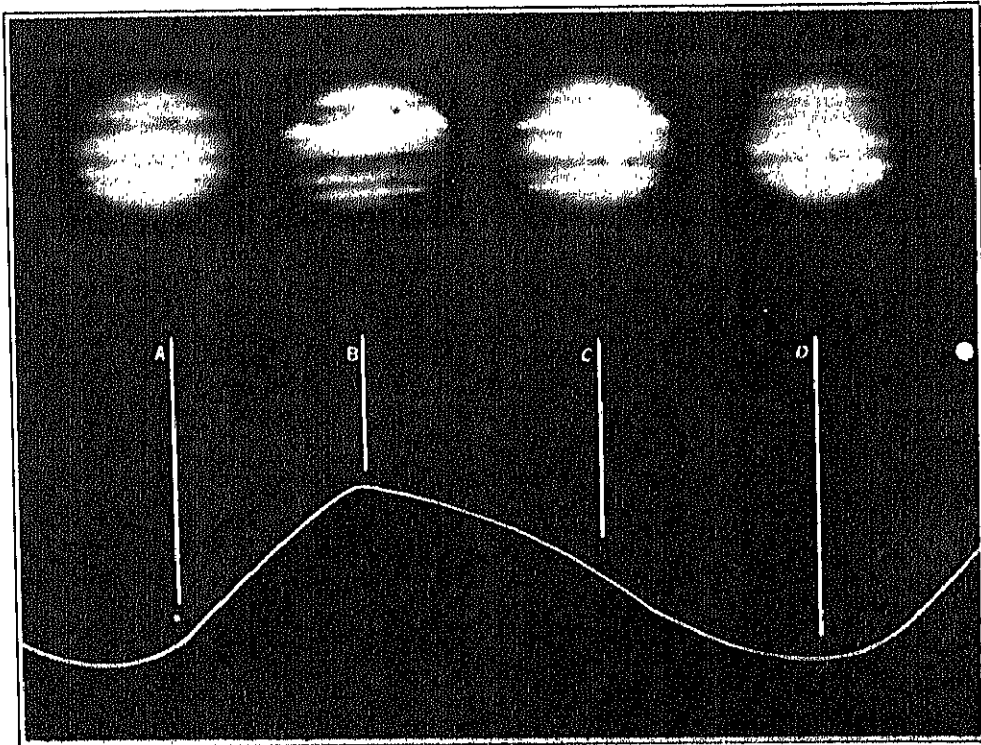
It is presumed that all the elements of structure were at first of low density and great in volume. Particles at the equator receiving successive increments in velocity eventually described orbits about the sun in the form of complete encircling rings. Additional impulses expanded the rings, while the sun's radiating shell receded from them as its volume grew less through the loss of sustaining kinetic energy. Under the mutual gravitation of their respective particles, the rings have developed into the planets whose eruptive activities, in turn, have produced the satellites.

An implication of the hypothesis is that a mass of particles in space under kinetic reaction does not possess the attributes of a sun or a star until it has developed the units of structure here enumerated and is in the actual process of creating its own magnetic field, and of replenishing the magnetic energy of its radiating shell through eruptions. From a condition of low radiation, the sun has passed through succeeding stages of increasing luminosity to a maximum, then through a declining light giving power to its present state. The evidence of its former competence as an eruptive, and consequently as a radiating body, is found in the great masses of Saturn and Jupiter, while its declining efficiency is indicated in the small masses and high densities of the terrestrial planets.



Mount Wilson

Fig. 17.-- Four Calcium Spectroheiliograms of a Single Sun-spot Cycle



Mount Wilson

Fig. 18.— Four Actinic Photographs Corresponding to a Single Eruptive Cycle of Jupiter

CHAPTER III

JUPITER AND SATURN

1. Sub-surface Eruptions on Jupiter

The Planet's Actinic Light.-- Photographs of Jupiter taken in blue and violet light give the relative distribution of the most intensely radiating particles in its visible surface. Where white belts or spots appear they may be regarded as composed of particles having a high radiating efficiency as compared with those of the conspicuous dark belts. As photographed in blue reflected sunlight, the units of its surface possess the power of reflection in proportion to their intrinsic radiant energy potential. It follows that photographs taken consecutively in the reflected actinic light of the sun will correctly depict the course of the planet's eruptive activities as they manifest themselves in its observable surface.

A continuous series of contact film positives from the Lick Observatory, which covers a period of several years, constitutes the illustrative material of the discussion with respect to Jupiter. The photographs used were taken in violet or ultra-violet light. My procedure has been to make enlarged negatives from the films and from these, positives, so that the details of Jupiter's surface could be examined at convenience. Four of these film photographs have been selected as exemplifying the typical features of Jupiter's surface at different periods of its eruptive cycle and are shown in Fig. 18 and 19.

The White Belts of Jupiter and of the Sun.-- The sun's radiating shell is of such volume that its luminous belts cannot be seen except as they emerge to visibility near sun-spot maximum, as at B, Fig. 17. Jupiter's white belts depict the course of the planet's eruptive activity in a transparent radiating shell of nearly zero luminosity. The planet lacks the eruptive efficiency to replenish its radiating shell at a rate greater than that which will supply luminous particles to

its erupting streams. By the time newly derived particles are incorporated as constituents of the radiating shell through kinetic and magnetic reaction, their intrinsic energies have been radiated into space. Such a rapid depletion of energy makes possible the emergence of phenomena incident to the planet's eruptive activity, which, in the sun, are obscured by a voluminous radiating shell.

When a period of eruptive activity has passed, the dominating forces giving configuration to Jupiter's belts are those arising from the high rotational velocities which were imparted to the laminae of Jupiter's atmosphere and radiating shell, whose planes are perpendicular to the axis of rotation. Thus in A, Fig. 18 and 19, the belts at minimum eruptive activity are broad, sharply outlined, uniform in luminosity, and exhibit a definite symmetry with respect to the broad equatorial belt. As represented in B at maximum eruptive activity, Jupiter is dominated by a conspicuous white belt in its southern hemisphere and by a dark belt in its northern. During a preceding period of quiescence, ionization and disintegration of atoms in the sub-surface homeoid, subject to Jupiter's electromagnetic field, resulted in the congregation of electrons in the northern hemisphere of the sub-surface reservoir and of protons, or positively charged particles, in the southern.

Relative Magnetic Fields.-- If an erupting column in the northern hemisphere were equal in mass and velocity to that in the southern, the electro-magnetic field which its moving particles produce would be of greater intensity in the ratio of about 1800 to 1. Hence, great strength of field will characterize the erupting column of the northern hemisphere, while great mass reaction will be a dominating feature of that in the southern. Since a great strength of field tends to suppress the oscillations of electrified particles, the northern belt will appear darker than the

corresponding belt south of the equator. The internal forces tending to maintain the integrity of the rotating lamina of electrons will be greater than those that hold the rotating positively charged particles to their latitude circle. Hence the southern white belt will be the first to undergo disintegration.

In B, Fig. 19, the sharp northern boundary of the white belt indicates that its high rotational velocity is maintaining its structure; in C its northern boundary has broken down under the attraction of the magnetic field created by the electron stream, and its particles may be seen flowing toward the northern dark belt in two broad surface streams, Q and R'. In D, although these streams persist, the particles of the white belt are seen to have been nearly all incorporated or neutralized by the electron stream.

Varying Rates of Rotation.-- During the cycle of eruptive activity from A to D, Fig. 19, the forces of eruption will vary according to the force curves of Fig. 11. With regard to the time in the period and the latitude of their occurrence, eruptions may be expected to coincide with those indicated in Maunder's chart, Fig. 16. When a cycle of eruption comes to an end, Jupiter's atmosphere and radiating shell, as a consequence of the differential eruptive activity to which its latitude belts were subject, will be left in a condition such that successive laminae whose planes are parallel to the equator will have different rates of rotation.

At the planet's minimum phase, the more rapidly rotating laminae will be represented by the dark belts, as in A, while its grey belts will overlie laminae of slower rotation. A higher rotational velocity in a given lamina will give its particles a sustaining centrifugal force which will reduce the kinetic reactions among them and thus result in their lower luminosity. It is significant, in this connection, that at minimum phase, A, the broadest dark belt is in the latitude of the conspicuous white belt and the great red spot of maximum phase, B.

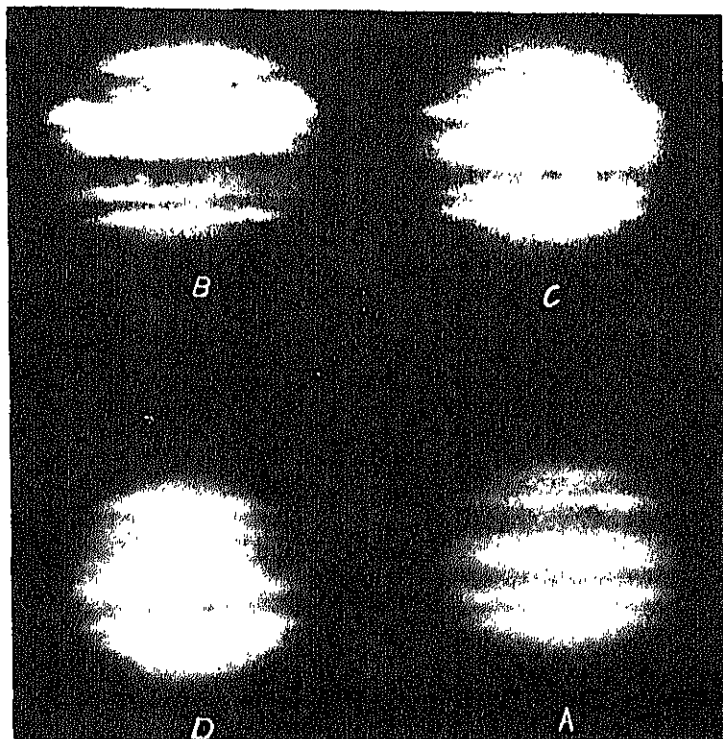
A high rotational velocity, increasing, in general, from the poles to the equator is a characteristic feature of Jupiter's surface phenomena. Definite markings at the equator indicate a period

of rotation of $9^h 50^m$, those in higher latitudes, a period of $9^h 57^m$. A significant fact with respect to the present discussion is that adjacent belts have been found to differ in rotational velocity by as much as 200 kilometers per hour or more, while the rates of rotation in corresponding northern and southern latitudes are quite different in several zones. And further, zones do not maintain the same rates of rotation from one year to another.

The Similarity of Jupiter's Spots to Sun-spots.-- An analysis of the configurations of spotlets in such a spot group as A, Fig. 13, leads to the conclusion that the penumbral material is composed of volatilized matter from the umbra mingling with particles of the photosphere. When the outer surface of the sun's gaseous envelope is penetrated by outflowing, inflowing, or inert particles, the umbra of the spot formed marks the region of the intrusion, while the penumbra is the spot's outer boundary in contact with the sun's gaseous envelope. A similar phenomenon of spot structure is observable in the double spot of Jupiter's northern hemisphere, D, Fig. 19 in which the umbra and penumbra may be distinctly observed.

A Great Eruption.-- The great red spot of Jupiter is the crest of an erupting column which rises above the radiating shell to a conspicuous visibility at the time of the planet's maximum eruptive activity as shown in B, Fig. 19:D. The internal forces of the column maintain its structure from b to c so that, to the observer, it appears of uniform outline throughout the arc, bfc. The spots, b of its outward, and c of its downward, penetrations of the radiating shell are distinctly shown in the photograph.

The superheated particles which form the core of the erupting column eventually break through their enclosing sheath of cooler particles and form a white belt in the latitude circle of the great red spot. The high rotational velocity of the white belt in relation to the arc, bfc, of the erupting column is attested by the bifurcation it undergoes as it flows past the obstruction. The dark lane in the wake of the erupting column, D-ward of c, is an evidence of the high differential velocity with which these units of structure pass each other.



Dates

B.--1927, Oct. 1
 C.--1928, Oct. 5
 D.--1928, Dec. 20
 A.--1929, Nov. 14

Lick

Fig. 19.-- Four Photographs of Jupiter

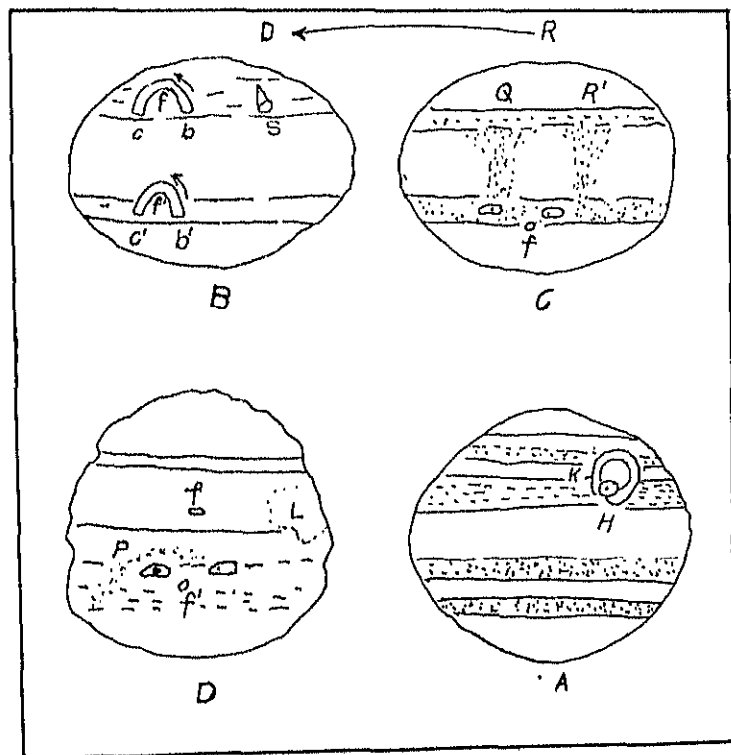


Fig. 19:D.-- Jupiter's Sub-surface Eruptions

If the erupting column issued in a radial direction the red spot would be circular in outline. Issuing tangentially, its elongation in an R-D direction will be a function of the forces producing the eruption and also of its conspicuousness as a phenomenon of the planet's surface. Its observed changes are a matter of interesting record. In 1878 and for several years following, it was the most conspicuous feature of the planet's surface, four times longer in an R-D direction than in breadth, and of a deep red color. Thereafter it became progressively less conspicuous, lost its redness, and changed in form to that of less elongation. These changing states of the great red spot are phenomena completely in harmony with the implications of the hypothesis.

Spots North of the Equator.-- The crest of an erupting column rises similarly to visibility in the dark belt of the northern hemisphere of photograph B. In C and D its activities are manifested in the two spots of the dark belt with a white spot between them. In C the details of the spots are evidently obscured by the voluminous northward flow of particles from the white belt of the southern hemisphere, while in D they appear distinct.

It is significant, with regard to a similarity of cause, to point out the phenomena of these spots which have a likeness to double sun-spots, as exemplified in Fig. 14. The Jupiter-spots, it will be observed, have umbra and penumbra, and are elongated in the direction of rotation; one precedes the other in the same latitude circle, and between them the white spot marks the manifestation of the activity which appears as the brilliant white matter bridging the space between, in double sun-spots. The white spot, f, which would be the crest of the rising column is a point at which many of the electrons of the core are set free to mingle and recombine with the positively charged elements in the radiating shell, or by their high rotational velocity, to maintain the laminar structure of its adjacent atmospheric belts. A column of particles, p, issuing from the R-ward spot and projected D-ward is clearly outlined on the white belt south of it. Its counterpart in the sun is the eruptive prominence.

Equatorward Progress of Eruptions.-- The white spot, f, Fig. 19:D, in Jupiter's

southern hemisphere, as shown in photograph, D, marks the crest of an erupting column which no longer has the projective force to rise high enough above the radiating shell so that the details of its structure may be seen. The decrease in distance between the points of eruptive activity in the two hemispheres--ff' in B and in D--are in anticipated agreement with Maunder's chart which gives the latitude of the activity throughout a cycle. In other words, the points of eruption occur nearer the equator as the period progresses.

An Atmospheric Spot.-- A spot which involves only atmospheric circulation may be seen at S in photograph, A. It lies on the border between the dark southern belt and the adjacent grey belt south of it, and thus appears to have been superinduced at this point by the differential angular velocity existing between the laminae underlying the two belts. The column of particles which issues in cyclonic motion from the nucleus of the spot remains intact above the surface after describing the arc, K. Incident to a loss in rotational angular velocity as it rises above the radiating shell, the column returns to the latitude circle of its origin R-ward of the spot nucleus. The shaded circular disc surrounding the nucleus represents the vortical approach of the returning particles.

The rising column of this activity on the surface of Jupiter has its counterpart in the quiescent solar prominence, and the spot conforms to those in the sun, some particles of which are found to be moving outward toward the observer, while others are moving downward toward the sun's interior.

The shadow of Satellite, II, appears at S in photograph, B, in which the umbra, penumbra, and shadow-cone are clearly outlined on the background of the planet's white belt. The distinctness of the shadow-cone indicates that some of the light reflected from Jupiter comes from particles below its outermost reflecting surface.

Jupiter's Spot Period.-- A consideration of the data at hand indicates that Jupiter's eruptive activity returns in cycles corresponding to the sun-spot cycle. If the observational data are available, it would be a valuable contribution to

determine Jupiter's eruptive period. It will be seen from the dates of these photographs that they are from different eruptive cycles. The four chosen seem to present to good advantage the characteristic types of surface phenomena corresponding to the epoch in the period for which they were selected.

2. The South Tropical Disturbance

An Atmospheric Phenomenon.-- The south tropical disturbance is taken to be a dense cloud which has a shorter period of rotation than the underlying solid surface of the planet. The disturbance has a longitudinal extent of 40,000 miles and occupies the latitude circle of the great red spot, of whose eruptive activity it is, no doubt, a product. The greater angular velocity of the disturbance causes it to gain a revolution on the spot successively, so that the two phenomena are in conjunction at intervals of about two years. At the encounter, the red spot seems to blend with the disturbance and move forward with it as if the erupting column were completely absorbed. The tangential eastward component of velocity imparted to the disturbance increases its angular velocity, as observed, and their final separation leaves the red spot moving forward at its former rate.

3. The Changing Longitude of the Great Red Spot

A Varying Period of Rotation.-- Observations show that the time intervals between successive returns of the great red spot to the same planetary configuration are not always equal. This means that the spot has been subject to changes in longitude with respect to an underlying nucleus rotating, presumably, with a uniform angular velocity. With respect to the hypothesis, it is implied that the erupting column producing Jupiter's great red spot is maintained at a surface longitude as a phenomenon of its zone of eruptions, as described in Chapter I.

When the zone front moves forward, the rotation period of the spot is shortened. A long continued interval in which

the rotation period remains the same implies that a surface of very considerable and of uniform tenacity is maintaining the position of the zone. The observational data with respect to its longitudinal changes are of paramount significance.

The great red spot has maintained a nearly constant period for the past thirty years, but between 1879 and 1885 it gained one half a period on this 30-year rate, and in earlier years its gain was even greater. It has been observed in latitudes whose difference, expressed in linear measure, is several thousand miles. The peculiarities of the period of rotation of the great red spot imply the definite relationship with an underlying solid surface which these deductions postulate.

4. Saturn

Saturn's Rings.-- That Saturn is in a state of eruptive development similar to that of Jupiter is attested by the changing conditions and similarities of its belts to those of the greater planet. The great distance of Saturn precludes the possibility of observing its surface features in any such detail as is possible in the case of Jupiter, but in its ring system a structure of fundamental significance is presented.

The atmosphere of a celestial body into which a stream of particles is being projected tangentially with forces which vary in a definite way through recurring cycles, will have impressed upon it angular velocities in excess of the planet's rate of rotation which will vary in the same order, from minimum angular velocity near the surface of the planet to maximum at the outer circumference of its atmosphere. The condition under which this differential angular velocity is impressed is shown in Fig. 20.

The line, AS, is taken to be a cross-sectional view of the planet's atmosphere as viewed perpendicular to the plane of its equator, FF' the forces which vary in a definite order throughout the recurring cycle of the planet's eruption period, and E the point of eruption on the surface. The continued increments in angular velocity which the particles at different

atmospheric depths receive at successive bombardments will eventually give the rings of particles of different depths at the equator, velocities sufficient to maintain them in orbital motion about the planet. In this manner the ring rises out of the planet's atmosphere with a configuration that depends upon the distribution of forces to which its atmospheric laminae were subject.

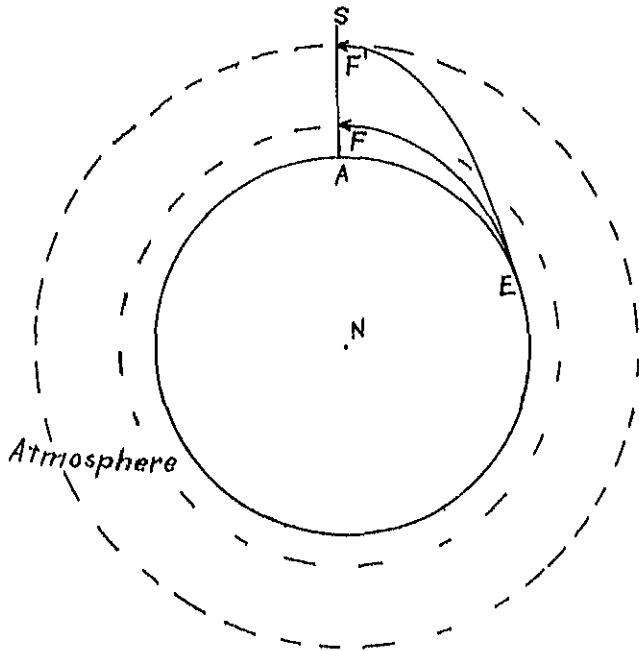
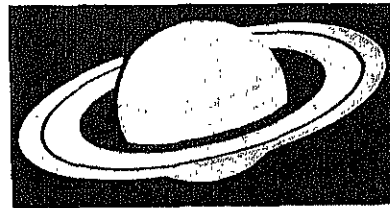


Fig. 20.-- Accelerating Forces

Divisions of the Ring.-- It will be evident from Fig. 20 that to secure a uniform distribution of particles throughout the ring, the tangential components of force, FF' , must vary uniformly from F to F' . Where this condition is not fulfilled, the ring derived will have definite vacancies in it where the forces were lacking to give particles the necessary angular velocities to fill them. The result of this condition is exhibited in Saturn's ring by Cassini's division. That Saturn reacts in a manner characteristic of a rotating body in regaining stability after an eruption is an implication of the hypothesis. Under these conditions, the ordinates of the vibration curve, as in Fig. 11, represent the relative magnitudes of the forces which react throughout a Saturn period to project particles into the ring.

In Fig. 21 the divisions of the ring are represented above the vibration curve of a celestial body as exemplified by a sun-spot cycle. If the forces which add particles to the ring at each succeeding Saturn period were of uniformly decreasing magnitude, as represented by the dotted line, BFC , there would be a uniform distribution of particles from its outer to its inner boundary. The forces which otherwise would have supplied the particles to fill the Cassini division have been suppressed by the type of vibration of the



Saturn

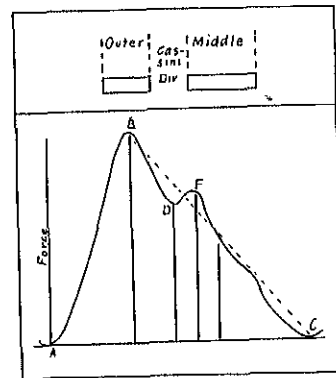


Fig. 21.-- Saturn's Ring

planet, resulting in a rarefaction at D . A rotating body in eruption lacks the reaction necessary to produce, relatively, the forces needed to give particles the angular momentum that will enable them to describe orbits in Cassini's division. In terms of the figure, the forces from B to F are of insufficient magnitude to supply particles to the space between the outer

and middle divisions of the ring.

Observational Verification.-- The white spots which have been observed at times on Saturn conform in every particular to the implication that they are the product of sub-surface eruptions as postulated in this discussion. As with the features of Jupiter's surface, those of Saturn are best recorded photographically, in violet or ultra-violet light.

In August, 1933, a white spot of large dimensions appeared on Saturn, which was extensively observed and photographed. A complete record of the subsequent changes that occurred in connection with the spot is contained in the photographs of it taken by Wright at the Lick Observatory. It was found that particles from the spot moved D-ward as postulated and described in connection with Fig. 12, and in a few weeks were distributed in a complete belt as illustrated of the sun and Jupiter, respectively, in E, Fig. 17 and 18. The white spots of Saturn exhibit a close compliance to the implications of the Hypothesis of Eruptions.

The form and existence of such an appendage as Saturn's ring implies that it is in a formative stage and suggests the possibility of observations having been made of phenomena incident to its acquisition of particles from an eruption. It is inferred that before incorporation takes place, the frictional encounter between particles acquired and those of the ring will produce an increase in illumina-

tion sufficient for the phenomenon to be observed on the earth. Observations in considerable number have been made of disturbances in Saturn's ring which tend to confirm these implications with respect to its development. Typical of these is a series of observations by Director R. G. Aitken of the Lick Observatory, who gives a vivid description of the phenomena observed.

"No very unusual phenomena were detected until Saturday, October 19. On that night Mr. Wright called my attention to two bright points on either side of the planet. My measures, made a little later, showed these points to be nearly symmetrically placed with respect to the planet, the two preceding ones being a little farther out than the corresponding points on the following side. It is certain that they were not visible on October 12, for . . . the seeing was good, and the ring was examined with special care. The measures of October 31, and later dates, place the knots farther from the planet than did those made on October 19.

"On November 1, a third knot appeared very near the planet's limb on either side. These knots were invisible on the preceding night, though the ring both then and on October 19 was brighter in this part than farther out." -- Observations of Saturn's Rings in 1907; L. O. Bulletin, Vol. IV, page 181.

CHAPTER IV

THE MOON

1. Surface Eruptions

Derivation of the Moon.-- The moon, according to the present hypothesis, has developed from particles launched into space by the eruptive activities of the earth. Under their mutual attractions, the particles were drawn together into a globe which has passed through the cooling stages exhibited at the present epoch by the sun, Jupiter, and Saturn. Its smaller mass has admitted of a more rapid rate of cooling than is possible for the larger bodies. The material of its radiating shell has been precipitated upon its solid surface; thermal equilibrium between internal conduction and the solar heat received has, apparently, been attained; and in its craters, mountains, and other surface features are recorded the evidences of the forces which once reacted to give them shape.

Related Activities.-- The surface features of the moon which appertain to its eruptive activities were derived from photographs

taken at the observatories in Paris, Yerkes, and Mt. Wilson. The five published herewith have been selected as presenting the typical surface phenomena which confirm the implications of the reactions considered. The relative positions on the lunar surface shown in the photographs are indicated in Fig. 22 as at P_1 , P_2 , P_3 , and \underline{Y} .

Two distinct types of surface material are apparent in photographs of the

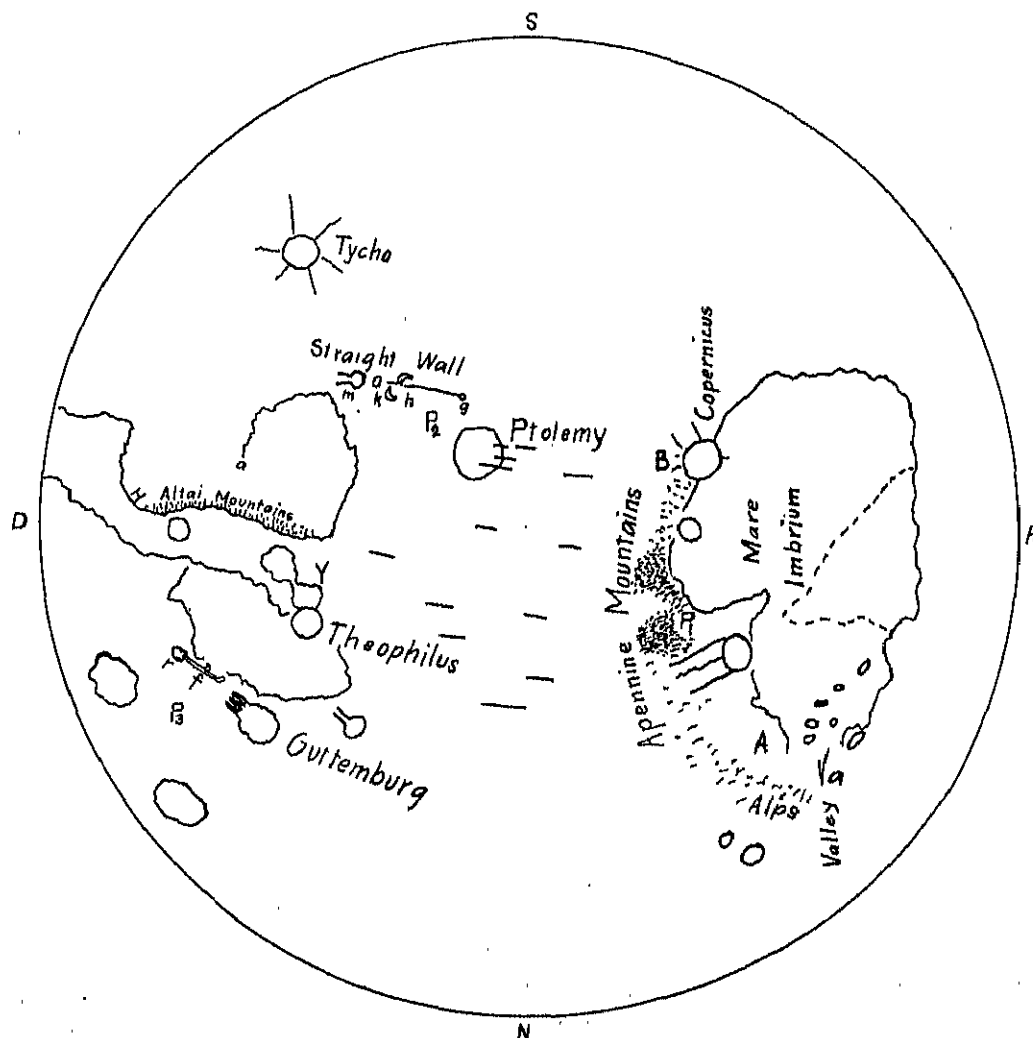


Fig. 22.— Lunar Eruption Features

moon, characterized as light and dark. That the light matter is of low density in comparison with the dark, is indicated by several contrasted phenomena. Where areas of the two different materials meet, the light matter has the higher elevation. Craters formed in the dark areas are small and infrequent compared with those of the light areas.

A Lunar Crater.-- The evidence at hand indicates that the formation of a lunar crater is an activity which has involved the light surface stratum as a local phenomenon, merely. The transformation of the matter in the base of an eruption tube on the moon's surface, as at *g*, Fig. 3, into an eruptive fluid which, in expanding, reacts to produce the crater, seems to have been the essential activity in their formation. Such a reaction establishes the fact of a higher temperature of volatilization for the dark matter of the supporting base, which remains intact throughout the activity.

The Theophilus Region, Y.-- The details of structure resulting from the activity which yields a lunar crater, with no evidence of subsequent obscuring reactions to obliterate them, are well preserved in the crater Theophilus as shown in Fig. 23. A well marked dividing line, *a*, Fig. 23:D, lies between the white matter of the crater wall and the dark matter which forms its base. In the dotted section the line is obscured by the shadow of the crater wall, but in other photographs taken at different lunar phases *a* is found to be continuous.

The level plane within *a* is the base which sustained the eruptive activity through whose agency the matter which once filled the crater was removed. The evidence of a lower density for the white matter outside the contour, *a*, forming the wall of the crater, is found in its lighter color, in its higher elevation, and in its apparent lack of compactness. Some portion of the D-ward wall appears to have fallen as talus to the base and may there be seen in obvious contrast in shade with the matter composing the floor of the crater. It is evident that the temperature which reduced the matter in the bottom of the crater to an eruptive fluid was ineffective in transforming the matter which composed its base.

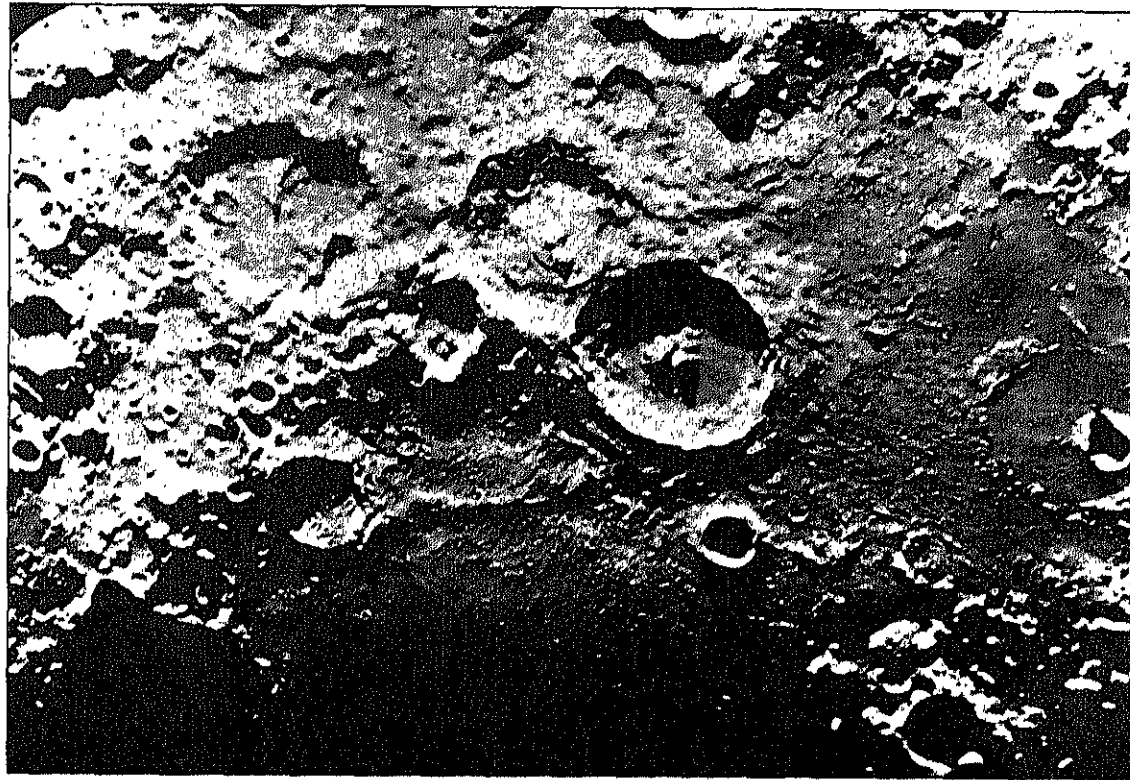
The manner in which the peaks at the center of the crater, Theophilus, rise sheer and precipitous, indicates that they were formed, not by an activity arising in the base of the crater, but as depositions from without. Their central position implies a causal relationship to the activities, nevertheless, which resulted in the formation of the crater.

The evidence of expansion before the eruption occurred is found in the portion of the crater wall erected above the surrounding lunar surface. The limit of this expansion was reached when the junction between the expanding wall and the stratum which capped the crater was weakened to the point of rupture. In some views, of which Tycho and Copernicus are examples, the crater cap served as a deflector to lay some of the erupted material down on the moon's surface radially in all directions when its disintegration began, giving rise to the surface features called rays.

The surface stratum that capped the crater broke up into triangular segments which, in the process of disintegration, were set on edge at the center of the crater bottom where they form its central peaks. Thus, of the white matter which once filled the crater, only the isolated peaks at the center remain, resting unconformably on the dark matter composing its base.

Evidence of Depositions.-- Crater, 2, Fig. 23:D, is of a diameter equal to that of Theophilus, and peaks emerge at its center as one of its characteristic features. That it is of earlier origin is attested by the phenomenon of its *SD* walls having been carried away by the activities which produced Theophilus. The details of the structure of crater, 2, are in marked contrast with those of Theophilus. No contour distinguishes the matter composing its walls from that which forms its base; the crater presents a nearly uniformly grey appearance from rim to rim. The evidence of a structural connection between the peaks at the center and the base of the crater upon which they rest are here completely lacking.

It is plausible to infer that when this crater was formed, its structural details were as sharp and clearly outlined as those of Theophilus. To activities



Yerkes

Fig. 23.— Theophilus

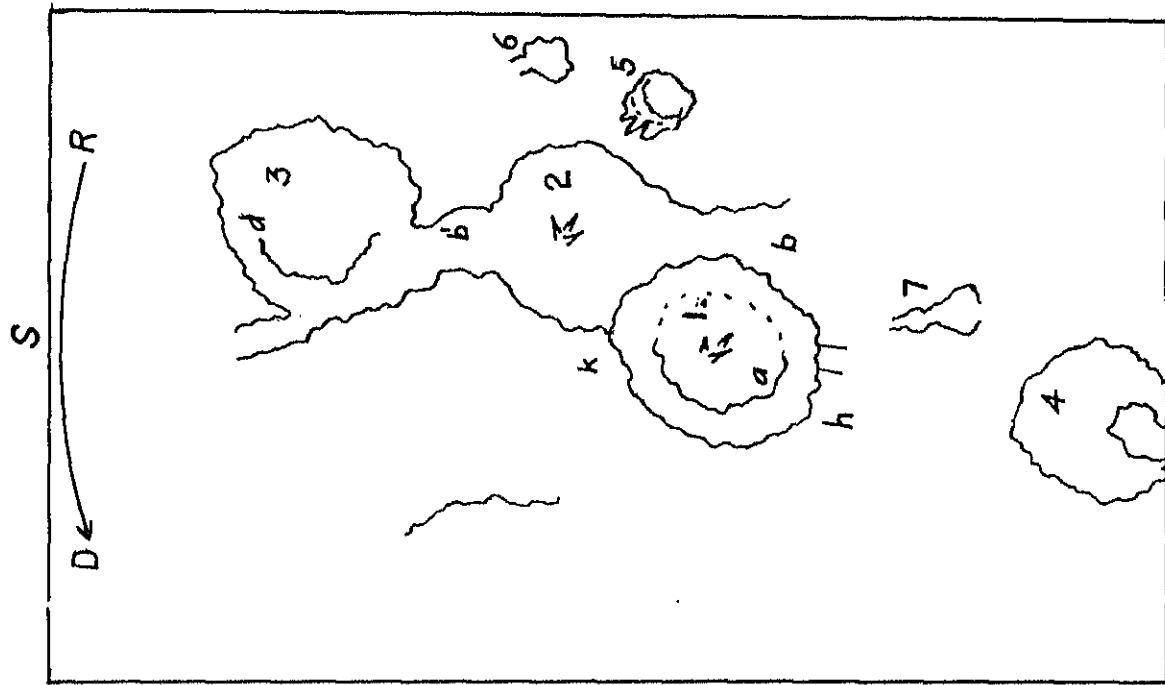


Fig. 23:D.— Effects of Forces

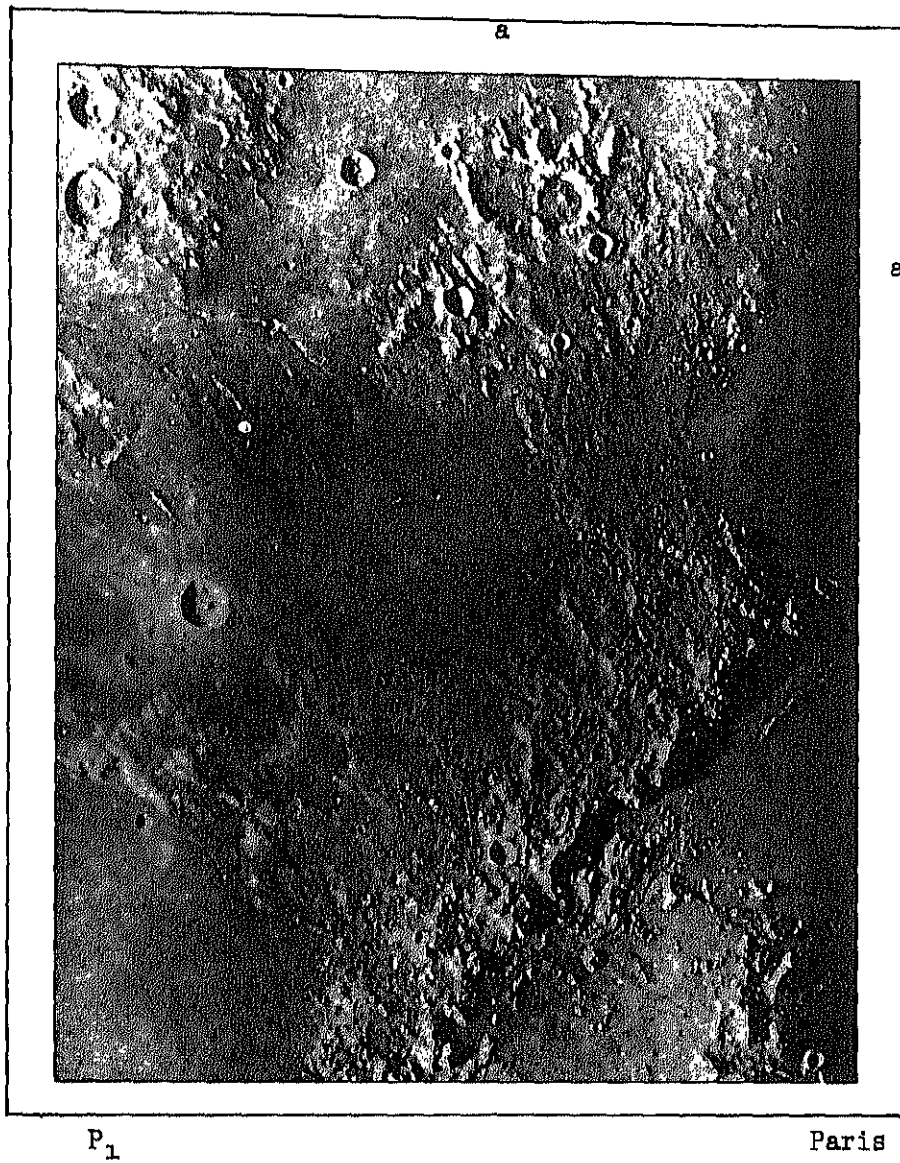


Fig. 24^o.— Lunar Apennine Mountains Bordering
the Imbrium Basin

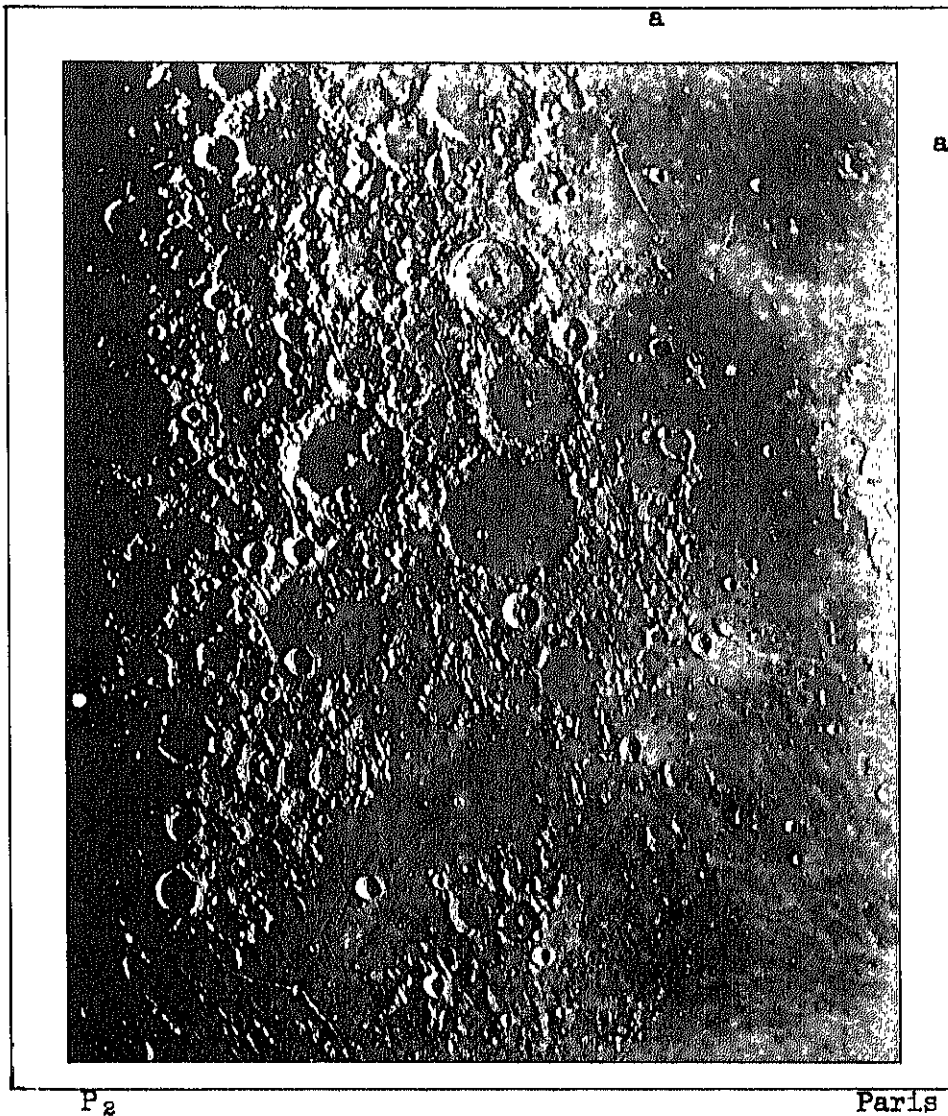


Fig. 25.-- Scorings on the Moon's Surface from the
Direction of Mare Imbrium

which have since taken place on the moon's surface outside the crater must be ascribed the agencies of their obscuration. The crater presents the appearance of having been covered with a precipitate of a depth sufficient to hide its dark level floor from view. Its central peaks, which must have stood as high above the crater floor at their formation as do those of Theophilus, scarcely emerge at this epoch above the precipitate which now so nearly fills the crater basin.

There is evidence of a flow of matter along the surface from the direction, NR, whose effect is evident in the small craters of the region. For example, the matter which flowed over crater, 5, was slowed up at the SD section of its wall and there overlies it in distinct banks or drifts. The SD wall of crater, 6, it will be observed, has been carried away completely. Evidence of a similar activity is found in adjacent areas of the moon's surface.

A Near Obliteration.-- Crater, 4, whose diameter is equal to that of Theophilus, is so nearly obliterated that the contour of its outer wall is outlined by the few peaks which project upward through the matter by which it was submerged. A renewed activity at the center of the crater is evidence of the volatilization of the matter which formed its submerged central peaks. It is evident that they were converted into an active eruptive state by their submergence. The condition implies that there is a certain maximum depth which the white surface stratum may attain by precipitation. Beyond that depth, liquefaction occurs to accomplish its disintegration.

To understand the reactions through whose activities new craters were formed and old ones submerged or destroyed, the major eruptive activity to which a celestial body is subject must be known in its application to the moon. The logical procedure, therefore, will be to consider the evidence presented by the moon's topography relative to the sub-surface eruption.

2. The Sub-surface Eruption

The Zone of Eruptions.-- From the lunar photographs studied, Mare Imbrium may readily be identified as the zone of

most recent sub-surface eruptions, and the chain of mountains, AB, Fig. 22, which includes the lunar Alps and Apennine mountains, as the front of the zone. This chain of mountains presents a nearly perpendicular declivity to the Imbrium plain and has a gradual slope on the side away from it. The implication of this configuration is that the surface stratum which formerly covered the plain was swept forward with the eruption and its disintegrated parts crowded together to form the bordering mountains.

A Section of the Apennine Mountains, P₁.-- The topography of the chain of mountains shown in Fig. 24 suggests the nature of the forces under whose reaction they were formed. A laminated structure is exhibited in this photograph, as if blocks of the surface stratum which were moved out of the Imbrium plain had been pressed together into upstanding sections of surface material. Some of the laminae, it may be observed, have fallen backward to the lunar surface and there form a coast range to the upstanding cliffs.

The slope on the opposite side of the chain presents the appearance of having been subject to an overwhelming flood moving D-ward in a direction away from the Imbrium basin. The old surface features shown near the south border of the photograph appear to have been severely shredded by the blast which passed over them. A long valley, it may be observed, was scored at a by a projectile which must have been of formidable size.

The Ptolemy Region, P₂.-- This photograph supplies evidence of the effect of scoring projectiles farther out on the moon's surface in line with the blast. The earlier surface features of this region, it can readily be observed, have been cut to pieces by a blast of projectiles from the direction of the Imbrium plain. Long parallel slits have been carved in the lunar surface here, by projectiles of relatively large dimensions.

The configuration indicated by the marginal reference, a, Fig. 25, implies that the Straight Wall was formed by an under-surface projectile. As represented in Fig. 22, the projectile passed beneath the surface at g and underwent fragmentation at h. The curved elevations in the section, k, indicate that severed portions of the projectile were laid down here,

beneath the surface. Remnants of the projectile eventually emerged and scored the crater-like depression, m, on the lunar surface at its point of issue.

The Guttemburg Area, P₃.-- This region of the lunar surface bears evidence of having received the descending stream of lava of which the core of the erupting column was composed. The crater Guttemburg, marginal reference, b, Fig. 26, presents a configuration of special significance with regard to the effect of a descending stream of igneous rock on the surface stratum of the moon. Due to their linear velocities and to their angle of descent, the particles of the stream were actuated by tangential components of force to move forward on the lunar surface. The effect of the reaction resulting from this condition is clearly shown in the crater, Guttemburg, which is a depression elongated in the direction from which the stream is presumed to have come. A mound of matter scooped out of the depression lies at the end farthest from the source of projection. The evidence supplied by this crater, whose configuration conforms so completely to that which might be anticipated of a descending stream of particles, is of special significance with regard to a similar activity on the earth.

The configuration, a, Fig. 26, is taken to be a projectile laid down parallel to the direction of its origin, nearly intact. It has undergone a partial bifurcation as shown at f, Fig. 22, while the end in advance has induced a disruption which resulted in the surface abrasion at r. Other configurations in this region lead to analyses and deductions of similar import.

An Intrusion of Lava.-- Among the significant features in this region of the moon's surface are those whose configurations confirm the implication of the igneous flood which must have followed the

activity that gave rise to lunar erupting streams. The dark matter which overspread the region, P₂ P₃, is evident in its darkened surface features, as presented in the photograph, Fig. 27. The area undergoing this inundation is clearly indicated on photographs taken at Mt. Wilson, to be within the contour, a, Fig. 22.

The elevation, H,--The Altai Mountains--marks the border of the channel by which the area was cleared of its igneous flood. The chain is, in fact, an undercut bank formed by the flow of lava from the adjacent regions. In this respect it is a unique feature of the moon's surface. Webb's description of the range is of suggestive significance with regard to this interpretation of its origin.

"Altai Mountains.-- This long range is almost the only high ground in this region undisturbed by eruptive forces. It presents rounded summits, and in the increasing phase of the moon its face appears as a bright line of 280 miles of cliffs."--Celestial Objects for the Common Telescope.--Webb.

The extensive igneous inundation of the moon is of special significance with regard to a similar condition on the earth, knowledge of which is supplied by geology.

The Horizontal Motion of Strata.-- A very considerable redistribution of matter, together with a change in the rotational state of the moon, must have resulted from its sub-surface eruptions. The total effect of these changes would be to create tangential components of force to move blocks of surface material horizontally along the surface upon which they rest. A discussion of the horizontal motion of surface blocks will be given special consideration with respect to the earth, but attention is called here to the suggestion of surface movements as exemplified in the accompanying photographs.

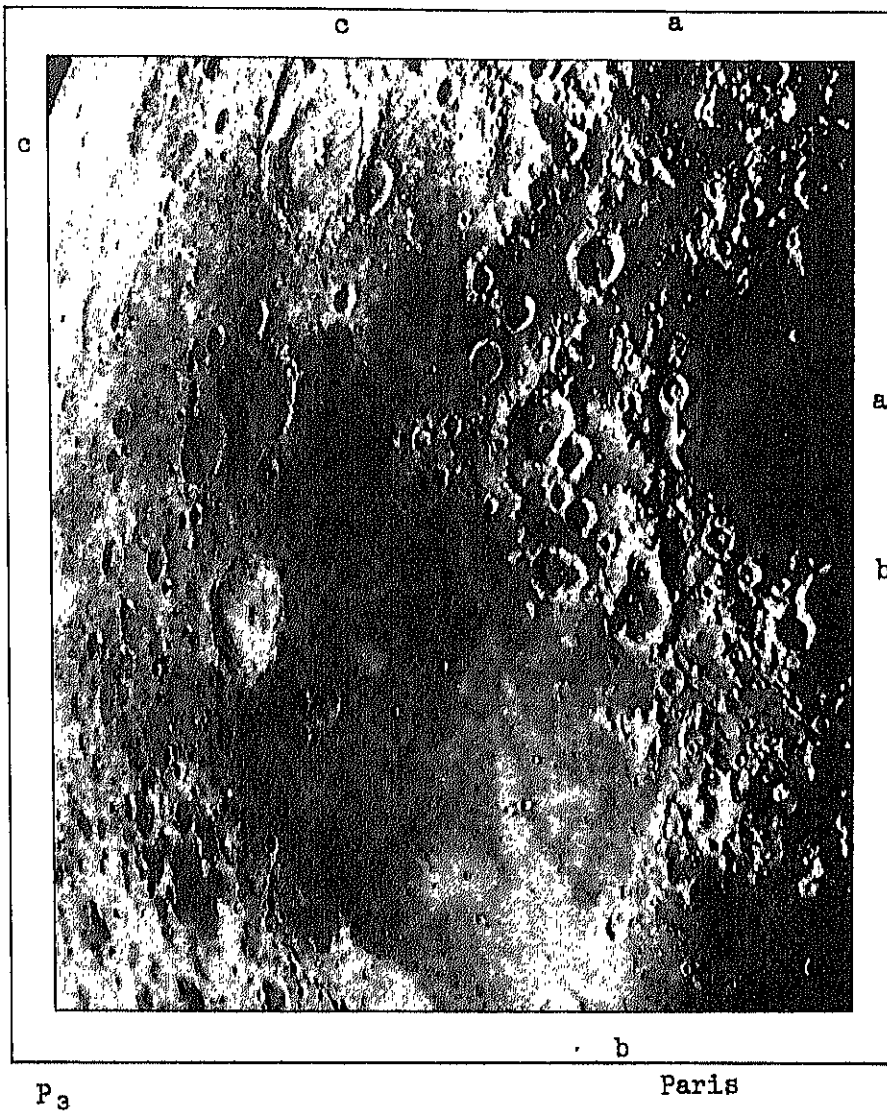
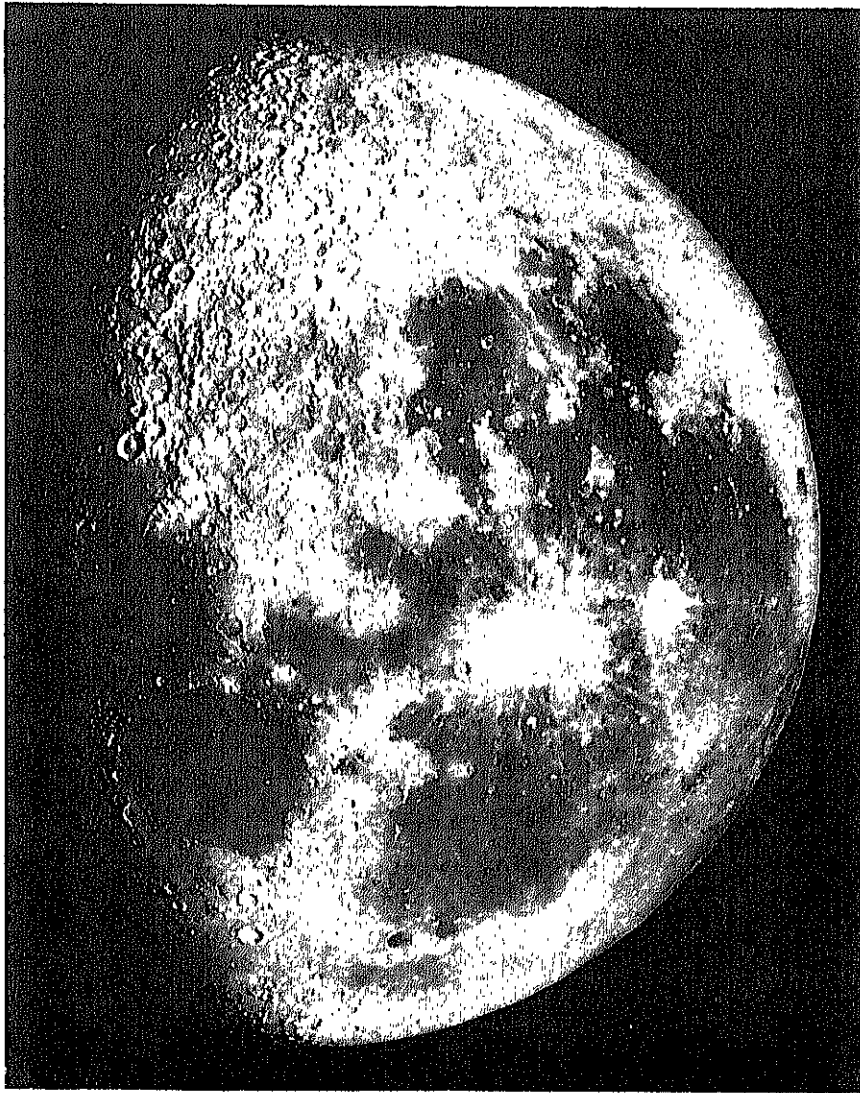


Fig. 26.— Depositions, as Evidenced in
Guttenburg, b



Mount Wilson

Fig. 27.— Gibbous Moon

CHAPTER V

THE EARTH

1. Initial Conditions

Concentric Homeoids.-- When particles in a state of wide distribution were brought together under the force of their mutual gravitations to form the earth, the elements of which they were components arranged themselves in concentric homeoids whose respective densities were greater in consecutive order from the surface to the center. It is presumed that, initially, all the atoms of the configuration were in a state of intense electrification and that free electrons in great abundance existed throughout the mass.

Through the loss of kinetic energy as radiant energy the configuration acquired a restraining outer surface at the initial epoch of its existence as a radiating body and thereby inaugurated the conditions for sub-surface eruptions. The elements in the homeoids immediately underlying the restraining surface were transferred in consecutive order to the radiating shell where the energies of their atoms were radiated into space. The consequent deposition of the de-energized atoms upon the solid outer surface gave it an ever increasing impenetrability, thereby increasing the force and magnitude of the eruptive activity.

The Structure of the Outer Homeoids.-- Eruptions and other agencies, it is evident, mixed and combined the surface elements, giving them a mean density less than that of the undisturbed element underlying it. The structure that the outer homeoids eventually attained may be postulated as in Fig. 28, where the line, EW, represents the concentric surface within the earth, above which lie the elements that have been transferred to the outside homeoid, while below it are those that have not undergone this transposition. Iron is represented as composing the homeoid immediately below EW, where its outer section is solid and its inner,

fluid. Other elements in a consecutive order, depending upon their densities and electrifications, occupy the homeoids toward the center.

The reactions to which the elements and compounds of the outer homeoid are subject will give the mixture which they eventually form, a universal pattern. Gravity will draw the heavier elements to the base of the configuration; erosion will wear down its excessive elevations; and depositions from water will cement the whole accumulation into a solid structure of rock. The metals and alloys of low temperature fusibility, in which the bases of the blocks are submerged, are conducive to their easy horizontal motion. A block actually afloat will move in reaction to the horizontal forces to which it is subject, whereas one not afloat will remain fixed to the sub-surface solid.

Changes in the dynamic status of the earth have given rise to forces that have shattered the solid surface homeoid. At the present epoch it exists in the form of upstanding blocks of nearly equal height, which vary in horizontal dimensions from islands to continents. Elevations above EW greater than the mean have been formed either by horizontal compressions or by the piling up of blocks one above the other. Depressions below the common level are due to the disintegration of blocks or to their absence.

A Change of Potential.-- When the outer homeoid was erected, the lines of gravitational force which maintained its component blocks in the configuration were perpendicular at all points to the surface, EW. Since no horizontal components of force acted on them, the blocks retained their positions with respect to the underlying surface. Sub-surface eruptions changed the dynamic status of the earth in a manner to effect a redistribution of its mass. Thereupon, EW ceased to be an equipotential surface; continents and islands,

large and small sections of the surface homeoid, became subject to horizontal forces under whose reaction they moved along the surface to positions where they reattained dynamic equilibrium and came to rest.

Some continents and some dismembered sections of continents have moved thousands of miles. Some have encountered other land masses and through their mutual horizontal pressure have erected high mountain walls at their common boundary or overtopped each other into high plateaus. In the following discussion it is proposed to show how these horizontal forces developed, give the direction of their reactions, extricate the transported continental sections from their contacts with other land masses, and retrace them to their former juxtapositions. To confirm the deductions, recourse will be had to historical geology whose data regarding the fossil remains of the earth indicate, to a high degree of certainty, what lands were adjacent to each other in former geological periods.

2. Lava

The Pressure of Liquefaction.--

The successive strata of surface blocks liquefy at definite pressures which may be designated pressures of liquefaction. Under whatever condition the critical pressure is attained, those sections of the surface stratum which surpass it become fluid. A consideration of temperature is omitted, since it enters the discussion as an invariant with respect to depth. Lava may be regarded, therefore, as liquefied surface strata and dealt with according to the laws of fluids, until its pressure falls below that of liquefaction and it solidifies.

Where strata liquefy under pressure there will be an immediate fluid adjustment with respect to density; the heavy metals will sink to the lower levels of the lava reservoir, and the lighter earth materials will rise to the top. It is due, probably, to this fluid adjustment that land formed from lava is especially rich in plant-producing elements.

This fluid redistribution of surface elements yields a structure of low cohesiveness when the lava solidifies,

such that it will undergo rapid disintegration under further stress. It is not surprising, therefore, to find in a line of lava flow that adjacent lands, usually of lava formation, are subject to earthquakes, volcanoes, and other manifestations of disintegration. It is significant that, in the built-up structure constituting the earth's surface homeoid, the anomalous admixture of elements of widely different atomic weights is readily reduced to a normal distribution with respect to increasing densities toward the center of the earth when it liquefies.

Atomic Disintegration.-- Where matter liquefies and becomes lava, the implication is that the internal forces of its atoms are exceeded by the forces impressed. Under this condition atomic disintegration will proceed at a relatively rapid rate and lava in a tube or reservoir will be subject to the kinetic and electrical reactions of its released electrons and protons. In the magnetic field of the earth the electrons and protons of a lava tube or reservoir may be separated into two groups such that at one point there will be an accumulation of electrons, at another a concentration of protons. Because of their relatively great kinetic energy and low mass, the electrons thus concentrated will produce an eruptive volcano, whereas the more massive, slower-moving protons will produce an even-flowing massive volcano. The two ways in which the pressure of liquefaction may be surpassed are indicated in Fig. 29.

Lava Tubes and Ridges.-- Where a barrier, C , opposes the forward movement of a surface stratum, the compression to which its units are subject will be inversely as their distances from the barrier. As represented in the figure, units at T' will be subject only to the forces, F' , those at T to the forces, $F + F'$. If strata of similar widths are farther out pressing toward the barrier, the total force acting on the surface stratum at T will be, $F + F' + F'' + \dots$.

Eventually, in a line parallel with the barrier, the pressure of liquefaction will be surpassed and an underground tube of lava, T , will be formed. With the flow of lava from the tube the surface above it will be upraised as the stratum, TT' , presses forward toward the barrier. In this way a lava ridge above the lava

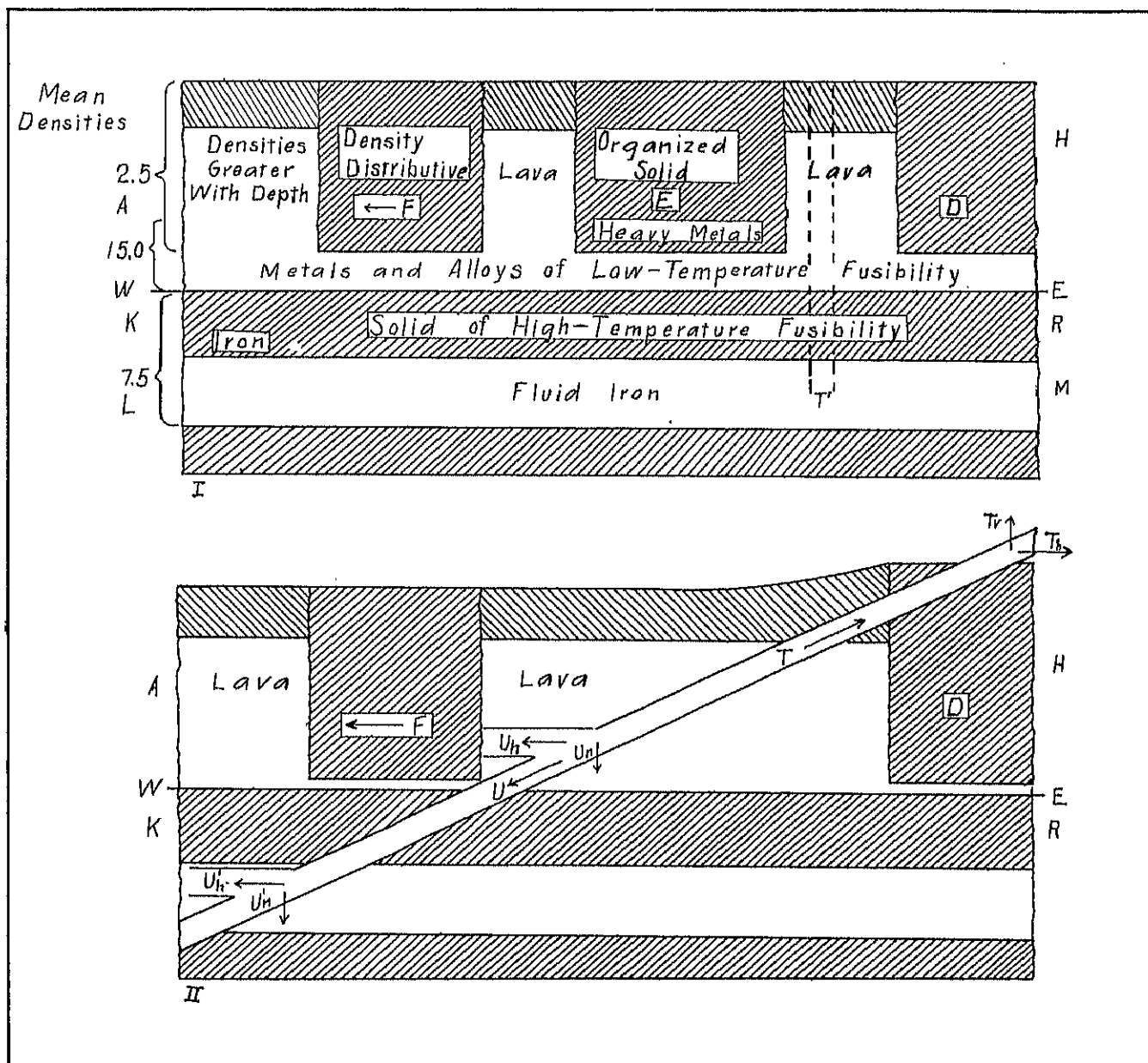
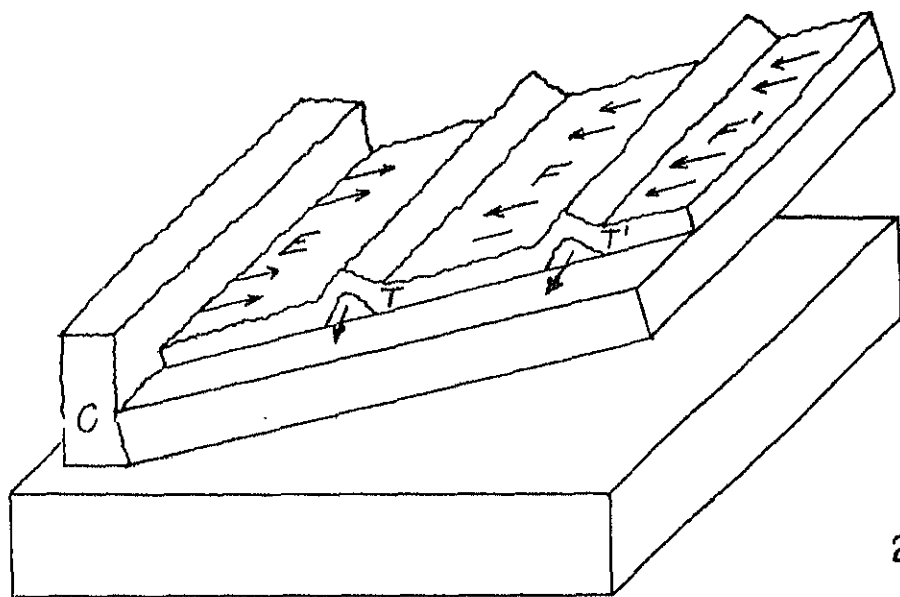
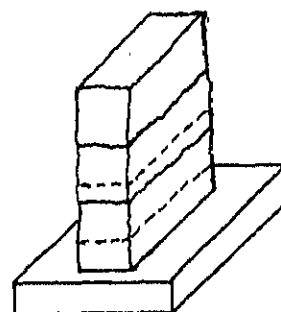


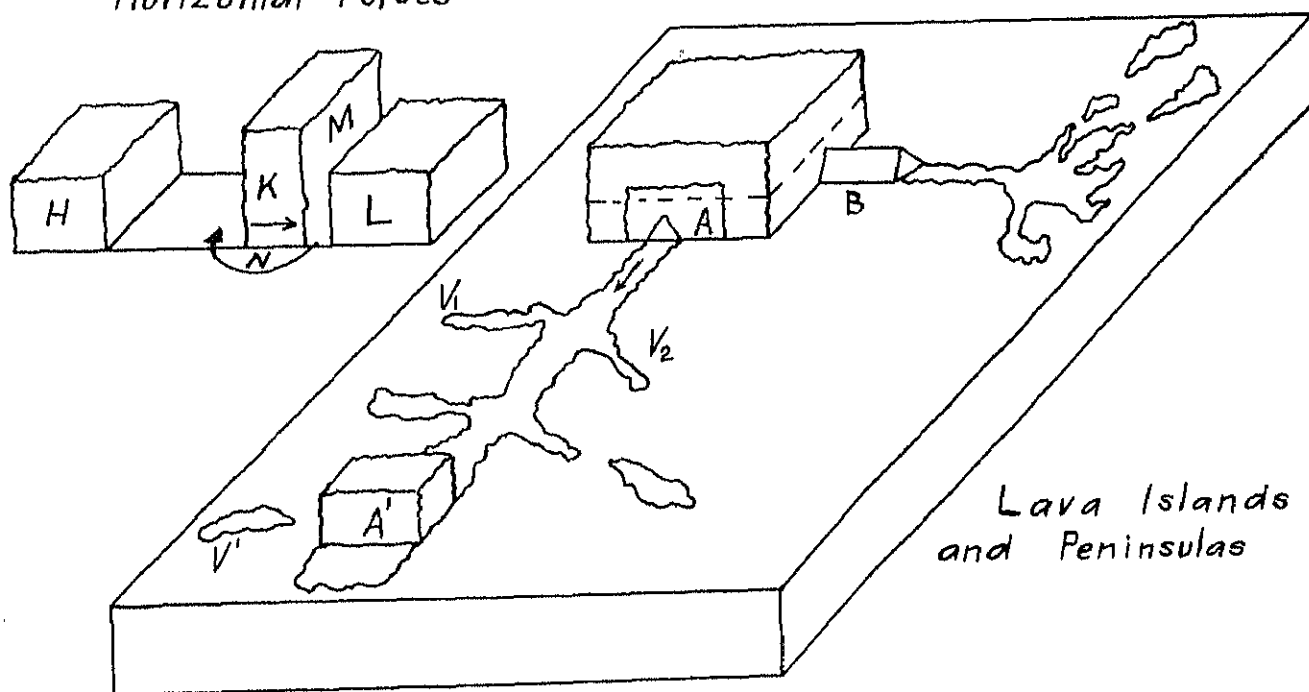
Fig. 28.— The Sub-surface Eruption



1. Lava Tubes and Ridges
Horizontal Forces



2. Superposition
Lava



3 Self-Extending Lava Tubes

Fig. 29.— Mountain-folding and Lava Tubes

tube will be formed. Mild earthquakes may be a concomitant feature in the formation of lava ridges, but volcanoes will be absent if the matter composing the ridges is sufficiently tenacious to prevent eruption.

As the pressure of liquefaction is successively attained at T and farther out, other lava ridges will be erected. In this manner parallel ranges of mountains of lava ridge type are formed.

Superposition.-- Where the surface stratum over a given area has attained a thickness sufficient to produce the pressure of liquefaction at its lower depths, as in 2, Fig. 29, it will be underlaid by a stratum of lava. Such a region may be regarded as a lava reservoir from which lava tubes may extend to lower levels.

Self-extending lava tubes will be established to conduct lava either from lava-forming ridges or from reservoirs as indicated in 3 at A and B. The lava stream may divide at its terminus into many branches which solidify quickly under surface pressures. By piling branch on branch at successive flows the main lava stream will erect a ridge through which a tube will be established to conduct lava to its terminal branches.

Italy may be cited as an example of a peninsula built up in this way. The source of the lava from which it was formed is beneath the Alps Mountains and high plateaus to the north of it. The volcanoes which occur at the terminus of the peninsula are activities by which the lava stream extends itself farther south into the Mediterranean Sea. The earthquakes of the peninsula may be regarded as manifestations of the adjustments which surface blocks undergo as pressures change with the flow of lava.

In case lava streams flow through the ocean bed they may form islands where the lava stream, in cooling, expands to such an extent that its surface lies above the water's surface. Sumatra may be cited as an example of an island formed in this manner. Through well established tubes, lava has flowed downward from beneath the plateau of Tibet to the ocean bed south and east of it, from which many lava islands, including Sumatra, have been formed. The active volcanoes and the many earthquakes in the region of Sumatra are manifestations of the changing pressures induced by the flow of lava from a high

elevation through its sub-surface lava tubes.

A lava tube will become self-extending where a fluid pressure greater than that of liquefaction is exerted at its terminus. The earth material will turn to lava at a depth below the surface at which liquefaction may be maintained, and the overlying solid surface will be pushed up into a lava ridge along which volcanic eruptions and earthquakes will occur to mark the position of the extending tube.

A Moving Section of Surface Stratum.-- A surface block afloat on a stratum of lava as represented at A', Fig. 29 will advance at the head of the lava stream which follows its abrupt departure from the point of its origin, A. The manner of its advance is indicated in the blocks, H, K, L.

The block, K, is presupposed to be an organized solid of high pressure fusibility, while L is unorganized surface matter, relatively of low pressure fusibility, opposing its forward motion. The section between H and K is filled with lava under a pressure of liquefaction wherein the kinetic energy of its ultimate particles are continually increasing, due to the energy derived from its disintegrating atoms. Eventually, a section of L in contact with the face, M, liquefies under the increasing pressure, and the lava formed flows around the block, K, as indicated at N, or upward as a volcanic activity, thus admitting of a forward motion of the block. The section of the tube between H and K will thus be continually replenished with atoms whose disintegration furnishes the kinetic energy for a further forward motion of the block.

A surface block thus launched and propelled along will come to rest only under the condition that the pressure in the tube between H and K fall below that of liquefaction, or that strata in the direction of motion be encountered whose pressure of liquefaction surpasses that of the moving block.

The block, H, represents the section of the tube traversed from A to A' in 3. After the passage of K, H, will retain its fluid state if the pressure head at A is great enough to maintain the pressure of liquefaction in the tube. With respect to the matter under consideration, the

block, H, sustains the reaction by which K is moved forward.

If a surface block moves across an ocean area, it pushes up before it the debris of the ocean bed ahead of it into the block, L. As a consequence, where such a movement is in progress, the greatest ocean depths will be found on the side from which the block has moved. Japan exemplifies all of these conditions. Its volcanic activity and frequent earthquakes, and the great ocean depth west of it, indicate that it is moving toward the continental mainland of Asia through the activities here considered.

Volcanoes and Earthquakes.-- Earthquakes are movements of blocks of the earth's crust made possible by their being afloat on a sub-surface fluid stratum and subject to its varying fluid pressures. Volcanoes are surface eruptions of lava where it ceases to be confined to lava tubes or reservoirs. Both activities, therefore, are traceable to the same basic cause--the presence of liquefied rock. The manifestations of earthquakes supplement those of volcanoes in characteristic ways, and their respective distributions, as shown in Fig. 32, 33, 35, and 36, indicate that they have a special significance with respect to the dynamical status of the earth.

4. Forces and Reactions Due to Sub-surface Eruptions

In giving up their kinetic energies as radiant energy, celestial bodies follow universal laws. The course of their activities, therefore, will be similar, subject only to the modifications imposed by their differences in physical states, such as those depending upon mass and rotational momenta. It follows that the sub-surface eruption, through whose activities the luminosities of the sun and stars are maintained, has been an important factor in determining the positions and contours of the earth's surface features. The problem of the earth, therefore, may be approached in the expectation of finding the effects of the sub-surface eruption impressed in large and unmistakable terms upon its surface features.

In Fig. 28 T represents the eruption tube at its inception when it is per-

pendicular to the surface, EW, and T its position after it has developed to the point where it has a forward inclination from the vertical in the direction of the earth's rotation.

A Figure of Forces.-- The representations in II, Fig. 28, are of the forces and reactions of the sub-surface eruption; T is the force with which particles are projected from the eruption tube above the earth's surface, and U is the reaction sustained consecutively by the sub-surface homeoids.

The surface block, D, will be subject to vertical and horizontal components of force due to the column's stream velocity. The vertical component, T_v, will lift one block above another, so that at the point of eruption an elevation several blocks high may be erected. The horizontal component, T_h, will crowd D and similar blocks against others to the east of them, thus producing a declivity having an eastern, downward slope. Lava tubes, produced by the forces, T_h, would lead to volcanic activities and lava flows east of the zone of eruptions, as at E, Fig. 30.

North-south Zones of Eruption.-- Maunder's chart of sun-spots and the behavior of Jupiter's spots indicate that the eruptive activities of a heavenly body begin coincidentally at a medium latitude in both the northern and the southern hemisphere, and as the period progresses they occur continuously nearer the equator, as represented in Fig. 30. In this way a north-south zone of eruptive activity will be established in each hemisphere in approximately the same longitude. The blocks erected into high elevations at successive points of eruption will thus form a range of rocky elevations having a north-south extension. The horizontal force, T_h, will have a disintegrating effect upon surface blocks as the erupting stream impinges upon them, such that there will be a tendency, as the destruction proceeds, for the front of the zone of eruptions to move eastward.

An Effective Carrier.-- The two components of force, T_h and T_v in combination, will make the erupting column an effective carrier to transport disintegrated surface blocks--metals, igneous rock, land and sea deposits, and ocean waters--to distant points on the earth's surface. Immediately east of the zone of eruptions there will be an extensive influx of ocean waters

under conditions such that the flood carries with it the disintegrated materials of its origin--its living creatures, its fossils, its clays, salts, and minerals. This matter, quickly superimposed upon the land as the agitation due to its eruptive invasion subsides, will constitute a marine deposit above which land deposits and erosions will appear. Thus as sub-surface eruptions succeed each other, an alternate succession of marine and land fossils will be erected east of the zone of eruptions. This overflow on the earth has its counterpart on the moon, as shown in Figs. 24 and 25, photographs of the lunar Apennines and adjacent regions. It is to be anticipated that the stream of particles projected eastward through the eruption tube will have a definite range of projection, as on the moon, and that the point of its descent to the surface of the earth can be located without difficulty.

West of the Zone of Eruptions.-- A horizontal component of force, U_h , equal to T_h , will react westward on all the sub-surface homeoids which the eruption tube encounters toward the center of the earth. Its reaction will be such as to renew the activities of formerly established lava tubes which moved surface blocks westward at former epochs and to launch other blocks on similar westward journeys. This movement of surface blocks from the region west of the zone of eruptions will be along latitude circles, as indicated at L and L' , Fig. 30.

Components of Force Directed toward the Equator.-- Within fluid homeoids having no surface outlet, the reaction of U_h' , Fig. 28, will be to produce counter-flows opposite to the direction of rotation, such that the oblateness of the surface, EW , will be decreased. The resulting change of figure will impose a horizontal component of force upon surface blocks directed along meridians toward the equator, as indicated at M and M' , Fig. 30.

It is implied that the formation of a surface stratum on the earth had its inception at the poles. As eruptions transferred matter in increasing quantity from sub-surface homeoids, withdrawing from it electrons and protons in the process, the surface stratum in the polar zones increased in thickness and extended farther toward the equator. Eventually the stratum in each hemisphere emerged as

land, while the waters of the earth were incorporated as an extensive ocean between the polar areas, as represented in Fig. 31.

Geology furnishes abundant evidence of the presence and effective activity of an agency, not at present operating, by which materials of the earth were transported from one position to another on its surface. One line of evidence exists in the drift which was intermingled with the ice sheet of the North American Continent and carried forward to become an extensive deposit at its terminus. The intermingling of this earth material with the deposition of ice exemplifies the process by which the polar strata in each hemisphere were built up. The drift must have been transferred from the place of its origin on the earth to the ice sheet by an agency of greater effectiveness than any at present known.

If this is the true order of development of the earth, its earlier fossils should indicate that there were two regions, the northern and southern hemispheres, whose flora and fauna were of independent origin and whose isolation was maintained for a considerable geological period. The region between the two land areas was kept clear of stratum by recurring sub-surface eruptions.

The figure resulting from this process is one of dynamic instability. Instead of being an oblate spheroid with its equatorial diameter greater than its polar, this development gives it a greater polar diameter. As a consequence of its anomalous figure, each unit mass of a polar cap will be actuated by a horizontal component of force directed toward the equator as represented by M and M' , Fig. 30. With continued deposition the stratum in each hemisphere attained a depth such that a pressure of liquefaction existed continuously at the base upon which it rested, so that, instead of being solids firmly attached to a stable base as in the period of their development, the polar caps came to be solids in unstable equilibrium afloat on a stratum of lava, as represented in Fig. 31. Eventually the lower margins of the caps gave way, the caps themselves disintegrated, and the dismembered segments moved toward the equator where, as they encountered segments from the opposite hemisphere, new forms of surface contours were erected.

Two Types of Surface Disintegration.-- During the period of quiescence between sub-surface eruptions a disintegration of atoms takes place in the underlying fluid homeoid, and a concentration of electrons occurs in the zone of eruptions north of the equator, and of protons south of the equator. As a result of this type of electrical separation a greater mass reaction takes place south of the equator. The north polar cap will divide into small sections because of the greater kinetic energy of the electron eruptions and the relatively lighter mass of the north polar cap, while the more massive south polar cap will separate into large sections with the lines of its division coincident with meridians.

5. The Pacific Region and Asia

Zones of Eruption.-- The Cordillera of North and South America are readily identified as the zones of sub-surface eruptions. The surface blocks of which these mountains are composed have been piled one above the other, leaving their sides exposed, in many cases, as perpendicular cliffs. The heavy metals of their lower strata have been brought to the surface through the eruptive reaction to which they have been subject, where they have become readily available in the gold, silver, copper, and other mines of these regions. A precipitous western slope and one more gradual to the east, as would be anticipated, is characteristic of these

mountains. The high elevations erected have resulted in producing a pressure of liquefaction at the bases of these mountains so that they rest upon a fluid stratum of lava. For this reason they are subject to both volcanic and earthquake activities except where the instability has been removed by lava flows.

The Pacific Area.-- The regions immediately west of the Cordillera are free of surface stratum, and since it is presumed to have moved westward and equatorward, the logical procedure will be to examine the lands to the west to determine what evidence they present of having been, at a former

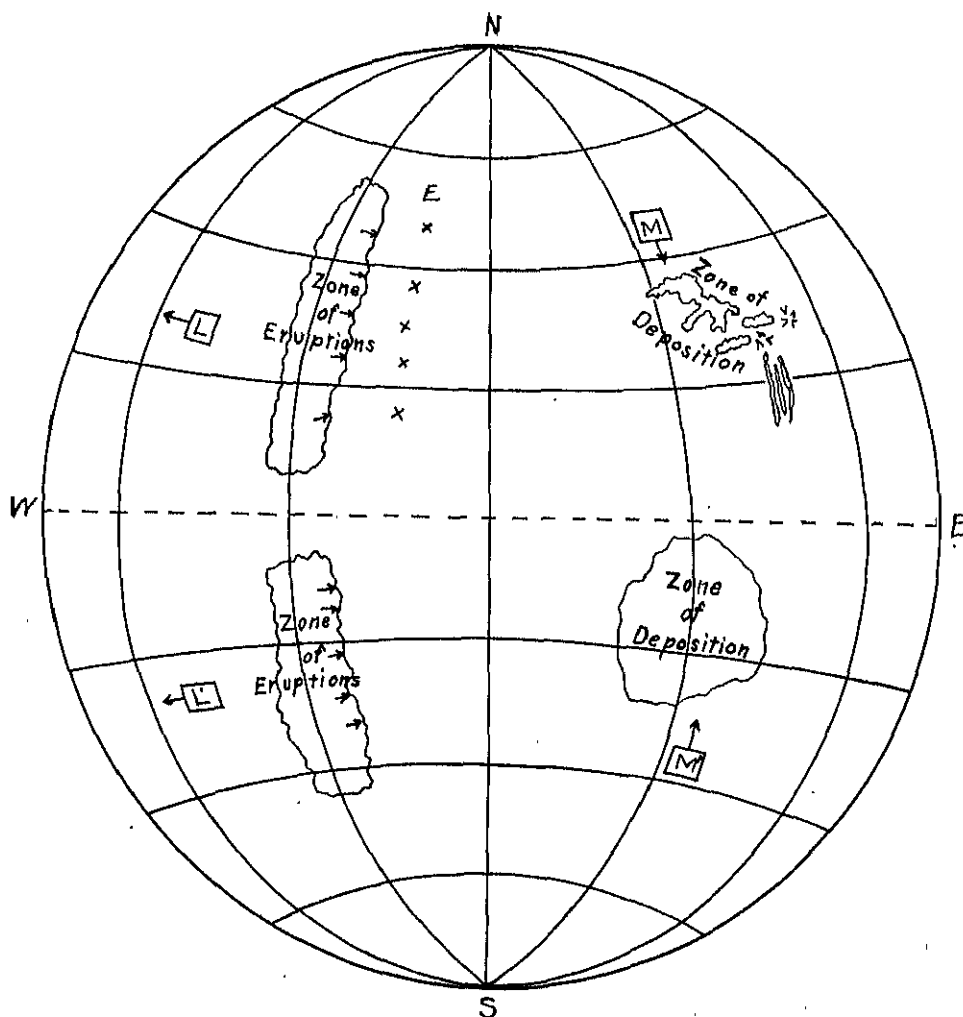


Fig. 30.-- Zones of Eruption, and of Deposition

epoch, in contact with the coasts, respectively, of North and South America and of having once occupied the Pacific area.

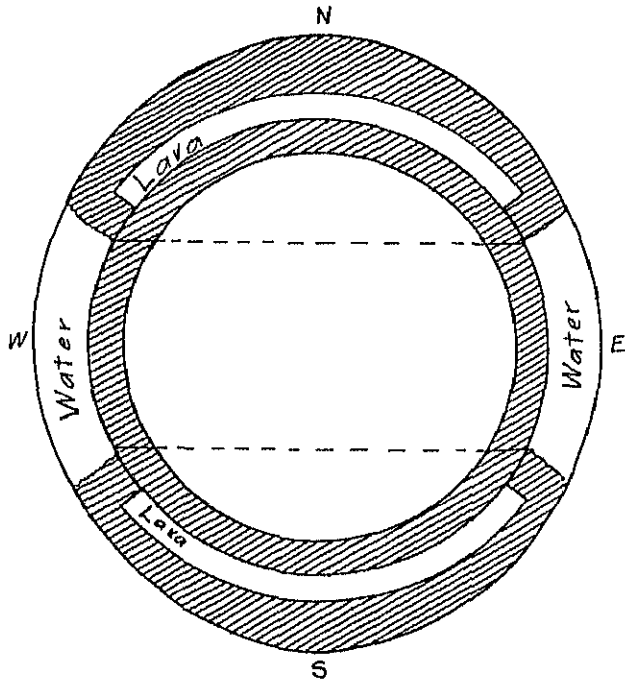


Fig. 31.--- Lava Beneath the Polar Caps

The first land areas encountered west of North America are the Hawaiian Islands, Figs. 32 and 33. Their present volcanic activity and the evidence they bear of having been in a more active state of eruption in recent geological times indicate that they are sections of the surface stratum in motion. The direction of their advance will have been westward along a latitude circle, since at the recent epoch of their motion, the forces acting along meridians will have been zero. By following the latitude circle of these islands to the North American coast, they may be identified as having been derived from the end of the Peninsula of Lower California which is in the same latitude. This group of islands, it is implied, started westward as a narrow section of surface stratum, the head of a self-extending lava tube.

The motion of the erupting column from north to south during a period of activity must have been an efficient agent for cutting the adjacent surface stratum into long narrow strips having a north-south orientation. It seems probable that

the stratum which once occupied the North Pacific area moved westward in the form of narrow longitudinal units which maintained their orientations but disintegrated into smaller sections with their westward progress. The eruptive activity that resulted in the formation of the Hawaiian Islands, it would appear, severed the Peninsula of Lower California from the mainland. Had the peninsula been less firmly attached at its upper extremity the whole strip of land, instead of a small section from its lower extremity, would have moved westward.

In addition to (1), juxtaposition, there are four lines of evidence which support the implication that the Hawaiian Islands had their origin at the end of the Peninsula of Lower California.

2. The only discontinuity in the coastline from South America to Vancouver Island occurs at the point, A. If the peninsula were moved westward so as to eliminate the gulf there would still be a gap between its lower extremity and the mainland. The clear implication of a once continuous coastline imposes the necessity of accounting for the stratum which once occupied this gap.

3. The sequence of active and recent volcanoes along the coast of South America and Mexico terminates abruptly at A, is resumed again at J, north of the peninsula, and from there is continued to Vancouver Island.

4. The earthquake activity along the western coast of Mexico undergoes a similar course of variation--a discontinuity at A and a resumption at J, which continues to Vancouver Island, Fig. 35 and 36.

5. The regions along the western coast of both continents, where earthquakes and volcanoes occur, are flanked on the east by high elevations which imply lava-producing pressures due to superposition. Where eruptions have occurred resulting in a sub-surface outflow of lava, the stratum remaining in the zone eventually rests on the sub-surface solid, and earthquakes and volcanoes no longer disturb it. For example, the outflow of lava which accompanied the movement of the Hawaiian Islands relieved the section, AJ, of the conditions which made it subject to volcanoes and earthquakes.

North of Vancouver Island.-- The Islands of Japan may be identified as having been derived from the western coast of North America. Between Vancouver Island and Alaska a definite indentation of the coast indicates the position whence, as a long narrow section of surface stratum, the islands originated. Moved slightly northward and retraced along their latitude circle, these islands would reestablish a continuous coastline where, at the present time, a definite discontinuity is apparent. The small islands off the coast between Q and L imply a recent severance of a section of surface stratum from the mainland of North America, and certain fossil beds found in them are the exact counterpart of those in Japan.

The discontinuities of earthquake and volcanic activities at Vancouver Island and their resumption in Alaska, together with the present moderate elevation of the highlands which border the region on the east, are all implications of the sub-surface flow of lava incident to the westward movement of the islands. The extensive lava fields in Washington, Oregon, and Idaho identify the region between Vancouver and Alaska as one formerly subject to a voluminous production of lava. From the continuity of earthquakes and volcanoes of the North Pacific area, it is evident that the flow of lava inaugurated by the movement of strata in this region is continued at the present time through lava tubes which emanate from the high elevations of Alaska and extend, by way of the Aleutian Peninsula and Kamchatka, to Japan.

Alaska, Kamchatka, and Northeastern Siberia.-- To reconstruct the region of the North Pacific area, Alaska should be moved in toward the pole, with Kamchatka folded in and reestablished along its western border. Northeastern Siberia has moved toward the Himalaya Mountains under the reaction of the forces, L and M, Fig. 29, giving rise to the compression ridges of Fig. 32, which signify that its surface stratum has been foreshortened in that direction. To return Northeastern Siberia to its former juxtaposition it should be outstretched northeastward and folded in against the North American continent in the region of Alaska.

The motion of Alaska in moving out from the pole to its present position, and

in having its land connections with Siberia severed, are clearly implied in its surface features. Its topography has been changed from a once orderly arrangement to one of confusion. Few equal areas bear evidence of having been subject to so great a volcanic activity in recent times as Alaska. Mt. McKinley, Mt. Wrangell, Mt. Blackburn, and Mt. St. Elias of the Alaskan Range are volcanic mountains which attain elevations, respectively, of 20,500, 17,500, 16,140, and 18,024 feet. They afford mute evidence of the reactions which have transformed strata in this region into lava.

6. The Hindustan-Siberian Continent

With the few outlying islands and peninsulas accounted for whose motions must have taken place in very recent times geologically, the problem still remains of accounting for the stratum which once occupied the North Pacific area and is no longer there. The solution of the problem consists in examining the continents farther west to ascertain what evidence they present of having undergone an invasion of surface stratum from this source. Under the presumption of such an invasion, the topography of Asia assumes an interpretative significance which suggests its correct analysis.

A Basic Formation.-- The earliest contact across the intervening equatorial ocean of the primitive earth occurred when a triangular segment, HJK, Fig. 34, broke away from the south polar cap and moved toward the equator, where it encountered a like segment, LJK, from the north polar cap in a similar movement. The upper strata of the two moving segments turned up their edges into mountains at the equator, as at JK, while their lower strata dovetailed each other and formed a high plateau north of the mountains. The solid surface strata remaining of the caps, thus relieved of their sub-surface stratum of lava, reattained stability by regaining contact with the sub-surface solid in the two hemispheres.

This basic formation is the Hindustan-Siberian continent, and the high elevations at the equator, erected as the two segments pressed upon each other, are

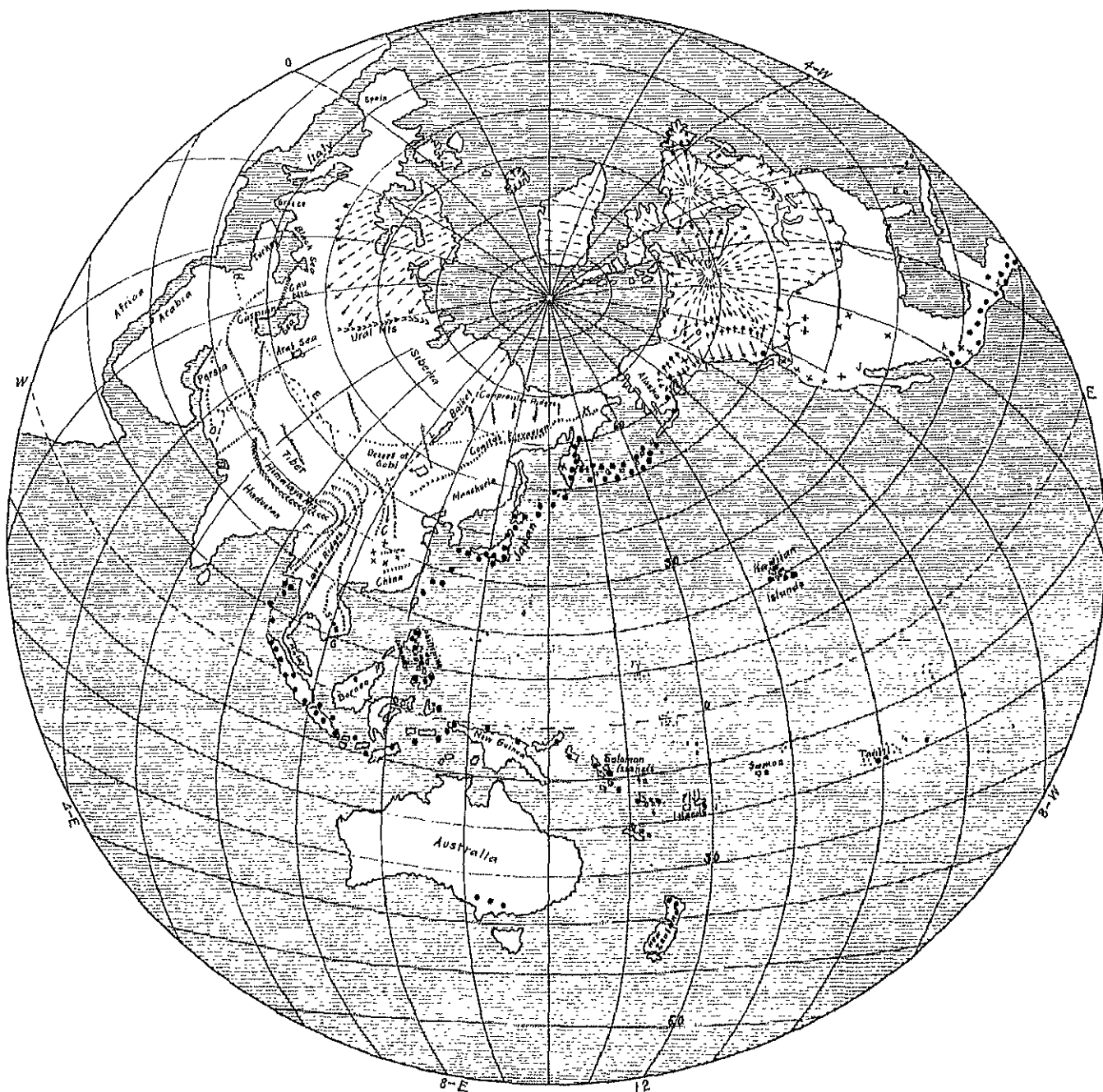


Fig. 32.-- The Pacific Area

- (a) Volcanoes: ●, Active and +, Recent
- (b) Lava Tubes, Ridges, and Islands
- (c) Ice Lines

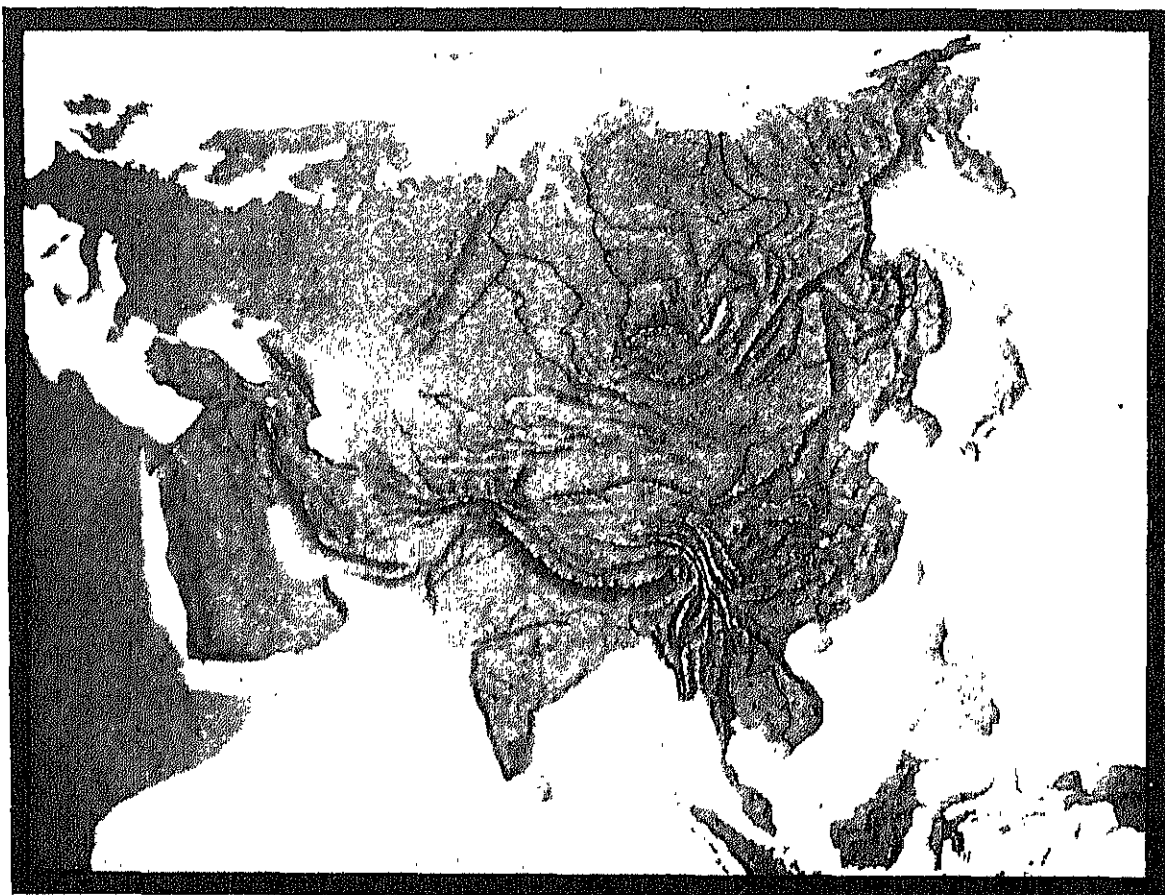


Fig. 32:D.— Invasion

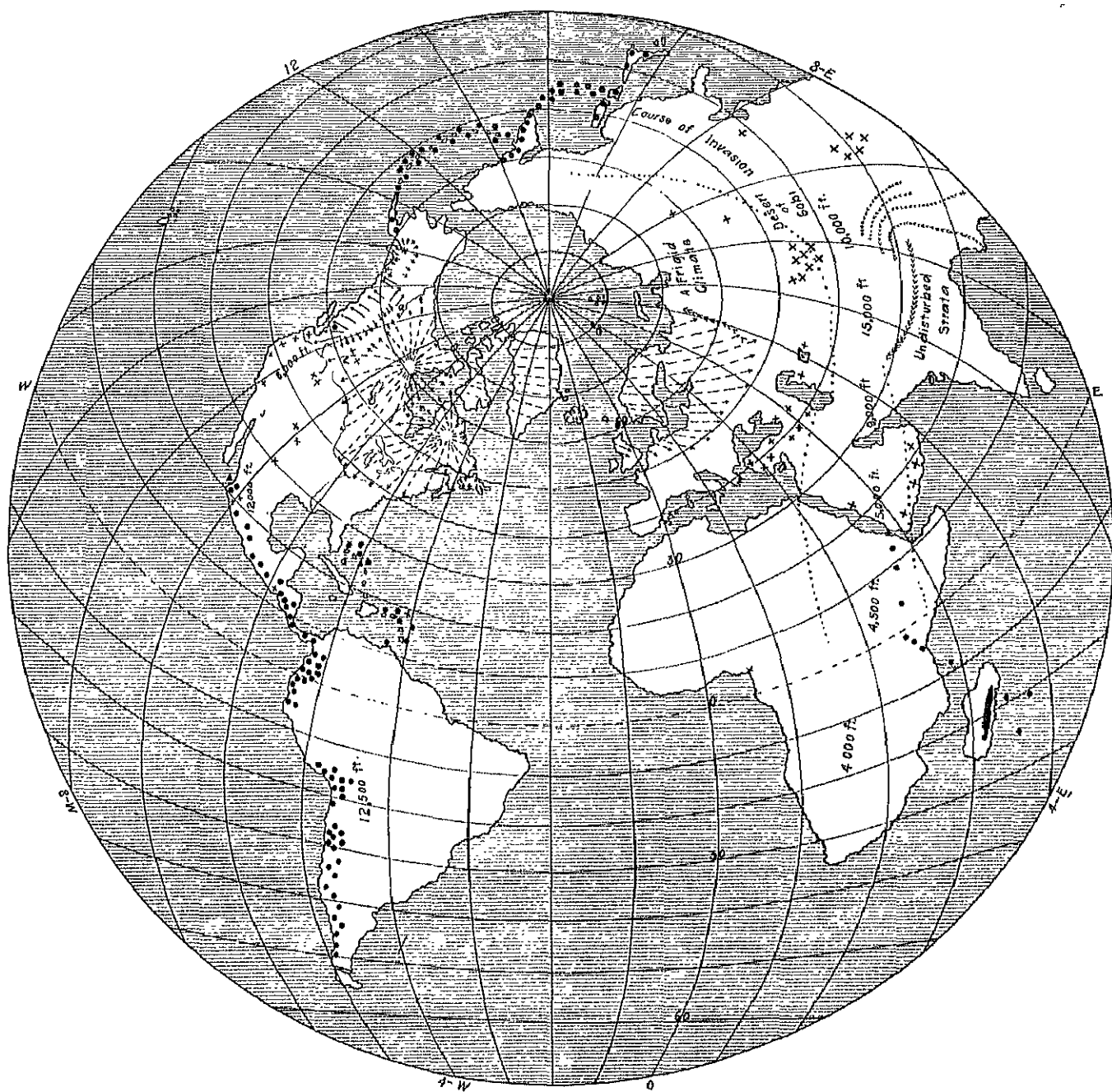


Fig. 33.— The Atlantic Area

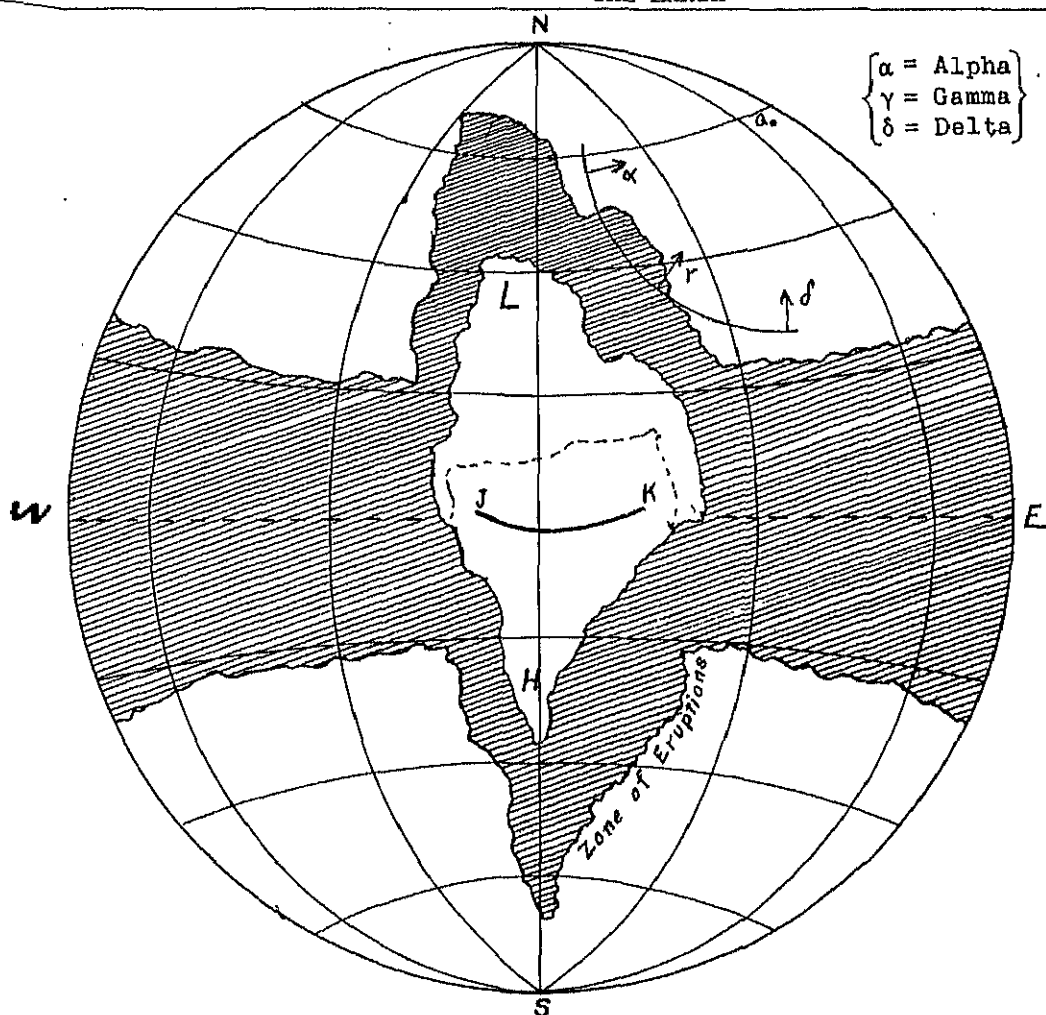


Fig. 34.-- Beginning of Polar Cap Disintegration

the Himalaya Mountains. The broken line, DEF, Fig. 32, gives the hypothetical outline of the Hindustan segment, while the meridian through the Ural Mountains and the one through Lake Baikal mark the western and eastern boundaries, respectively, of the Siberian segment. The Himalaya Mountains stand out as a phenomenon of independent and more ancient origin than other surface features of the region.

In the course of this encounter, the Hindustan-Siberian continent became a fixture amalgamated to the sub-surface solid homeoid which underlies it. Thereafter such strata as invaded the region under the stress of horizontal forces passed over or around the obstructions which the continent presented to their progress.

For a period before the Siberian segment moved southward, the contact of its southern margin with the sub-surface solid

was the only factor that prevented its earlier equatorward movement. During this interval, the horizontal pressure of outlying strata toward the margin produced a set of lava ridges parallel to it. When the southern margin gave way, mountain folding ceased, and the southward motion subjected the segment to warping and block-faulting as it moved into lower latitudes.

The restoration of dynamic equilibrium to the surface homeoid, induced by the movement of two continental areas toward the equator, inaugurated an epoch of extended duration during

which, from the mingling of life forms previously and independently derived, new flora and fauna, under tropical climatic conditions, developed. It is a noteworthy fact of observational geology that Hindustan and northern Siberia--areas on opposite sides of the Himalaya range--contain the most complete and undisturbed arrangements of strata to be found. The fossil beds of northern Siberia, a region now of frigid climate, certify to a development of plant and animal life at an earlier epoch such as could occur only under semi-tropical or tropical conditions.

An Invasion.-- Northern Siberia and Hindustan seem, therefore, to have suffered no invasion of surface stratum from the west such as to obscure the older fossil beds in these regions. But east of the Lake Baikal boundary and southwestward below the line, HK, Fig. 32, many different types of surface phenomena sustain the

implication of an invasion.

A relief map of Asia picturizes the effects of a motion of surface stratum from the northeast to the southwest, significant features of which are the compression ridges perpendicular to the direction from which the stratum moved, as indicated in Fig. 32. From the curved contours of the ridges in southern Asia, it is evident that the Himalaya Range proved to be an insurmountable barrier against which the invading stratum divided into two streams, one flowing westward across the plateau of Tibet, the other southward around the east end of the Himalaya Range, forming there a succession of lava ridges. Obviously, this range of mountains saved India from an inundating flow of surface stratum.

The region north of the Himalaya Mountains is one of abrupt ridges and high elevations, a topography in striking contrast with the gradual slopes and lower levels of India. The surface features of India are such as might have been anticipated for the whole of Asia had there been no invasion to obscure them.

The westward invasion may be traced to the Caucasus Mountains and Turkey through the continuity of the contour lines which were incident to the movement of the stratum north of the Himalaya Mountains. The invasion extended southwestward by the way of Persia and Arabia into South Africa, represented in Fig. 33. It is implied that Arabia was formed from the invading stratum which, in moving forward off the plateau of Tibet, bridged the space which intervened between the Hindustan-Siberian continent and Africa. In the interval that has elapsed since the formation of Arabia, erosion has produced the Red Sea and the Persian Gulf, two discontinuities in a once continuous land connection.

There is an increment in mean elevation along the course of this invasion, from 4,000 feet in South Africa to 15,000 feet in Tibet, which implies a sequence of causal relations in its formation. The high mean elevation at all points of the invaded region is significant in its contrast with the low elevation of northern Siberia, 300 feet, and with elevations of India, continental North America, South America, and Australia, each about 900 feet. In other words, the average eleva-

tion above sea level for the invaded region is about ten times that of a normal continental area that has been subject to no such invasion.

7. Volcanoes and Earthquakes in the Region Invaded

The active volcanoes of the north Pacific coast of Asia have been ascribed to lava originating in Alaska and flowing southward through self-extending lava tubes. The volcanoes of the south Pacific ocean and of the coasts of southern Asia are due to lava originating in the high lands of Tibet. The recently active volcanoes of the invaded region of Asia were an outlet for the lava produced by the horizontal compressions incident to the forward movement of the invading stratum. The outflow of lava by way of marginal volcanoes resulted in a folding of the overlying surface into the compression or lava ridges which characterize the topography of the invaded region.

During the terminal extension of lava tubes, islands may solidify out of the lava stream and at a later renewal of the stream activity be greatly disturbed or even broken into sections and moved forward in the direction of the flow. A group of lava islands usually presents features characteristic of this type of disruptive formation, advancement, and distribution. The same condition of advance will obtain if the invaded region is a continental area instead of the ocean floor. Volcanoes and earthquakes, therefore, will be concomitant manifestations of the active terminal extension of lava tubes.

Volcanoes in Alignment.-- The region of the invasion in Asia contains an extensive array of active and, more particularly, of recently active volcanoes whose alignment confirms the implication of an invasion and elucidates its past activities, Fig. 33. It will be observed that the recently active volcanoes occupy a marginal position with respect to the course of invasion from Manchuria to the Red Sea, with an interruption on the south marginal distribution marked by the Himalaya Mountains.

A notable increase in volcanic

activity is indicated at a point west of the Desert of Gobi and also in the south margin of the course directly opposite to it. Where the invading stratum encountered the Himalaya Mountains and split into two sections, one flowing south, the other west, the increase in pressure involved produced an acceleration in the rate of the stratum's conversion into lava such as to require a more voluminous marginal outlet. The volcanic mountains west of the Desert of Gobi and the inactive volcanoes across the course from it are the products of this increased marginal output of lava.

If the region between the Hindustan-Siberian continent and Africa was once a deep sea area that in the course of time was filled by the stratum which moved forward off the plateau of Tibet, the invasion may not have reached Africa for a decade after its appearance in Asia. It is significant in this connection that the sequence of recently active volcanoes which extends from Manchuria to the Red Sea is continued without interruption by a succession of active volcanoes from the Red Sea to the Island of Madagascar. The recentness of the stratum's advent into South Africa is attested by its active volcanoes as distinguished from those recently active, as of the Asiatic region. In its lakes of extreme depth, in its high voluminous waterfalls, and in the exposure of its heavy metals, such as gold, at the surface, Africa bears evidence of the invasion and of its recent occurrence.

The eastward deflection in alignment of the active volcanoes of Africa at a point five degrees south of the equator, Fig. 33, indicates that the invasion turned toward the eastern margin of the underlying continent where, by overflowing the continental shelf, a vertical stratum was erected which, in effect, increased the width of the continent. The island of Madagascar, formed in this way as an integral part of the continent, was severed at a later epoch from the continental platform (latitude, 5° S; longitude, 3^{h} E.) and moved southward with the advancing eruptive activity. It is significant that the line of active volcanoes from the Red Sea to Madagascar, which is, in fact, a continuation of a line of recently active volcanoes through Arabia, establishes a continuity of eruptive activity from Tibet

to Madagascar. The replacement of Madagascar to its former hypothetical position would straighten out the eastern coastline of Africa and remove the implication of a physical discontinuity which its isolated position suggests.

Earthquakes Supplement Volcanoes.--

The northern boundary of the region of present-day earthquakes in the invaded area of Asia coincides with the line of recently active volcanoes from Manchuria to the Mediterranean Sea, a coincidence which provides the proof of an intimate causal relation between them, and suggests its elucidation. Likewise, if due allowance be made for the discontinuity introduced by the Himalaya Mountains, it may be said that the southern edge of the earthquake region falls into coincidence with the sequence of recently active volcanoes which outline the southern margin of the course of invasion.

The implication of the representation is that the earthquake region is underlaid by a stratum of lava whose margins, under the stresses to which they are now subject, have been sealed against a further flow of lava. Consequently, the earthquakes throughout a part of the region may be ascribed to a marginal movement of the overlying solid stratum, reacting much in the manner of marginal ice on the shores of a large lake where it moves, breaks up and conveys the shock of its disintegration to the contiguous ice stratum. Certain regions near the center of the invasion appear to be so nearly afloat as to undergo no earthquake shocks.

Earthquake Bands Imply Lava Flows.--

The earthquakes represented by dark bands from Tibet to Sumatra, to the Persian Gulf, and to China--A, B, and C, of Fig. 35--may be ascribed to readjustments of surface strata superinduced by changing pressures within the lava tubes of the respective regions. The earthquake band, B, to the Persian Gulf completes the sequence of phenomena from Tibet to Madagascar whose interpretation involves a flow of lava. Likewise the band to A continues a sequence of lava phenomena from Tibet by way of Sumatra, Java, and Samoa to the region of Tahiti. It may be noted in this connection that the most violent eruption of modern times (1883) occurred in the island of Krakatoa in this line of activity

between Sumatra and Java.

The blunt termination of the band leading to China coincides with lava ridges which undergo a similar abrupt termination at C. The discontinuity implies that the lava tubes which underlie ridges from Tibet to this point are continued beneath the surface of China to the Pacific area without surface manifestations. An examination of the region beyond China for evidence of a renewal of activities incident to a continuance of the lava tubes to the South Pacific area shows that the Philippine Islands are in exact alignment with the earthquake band to C. The group of islands, as a unit, is elongated in the same direction and the region is notably subject to earthquakes and volcanoes. The implication is clear and unmistakable that the Philippine Islands were formed through the activities of the lava tubes whose ridges and earthquake band terminate abruptly in China at C, and whose further manifestations are apparent in the islands found in the line of their flow.

Geological observations in the islands supply interesting evidence in confirmation of these deductions as indicated by the following quotation: "It seems certain, from the frequency not only of large tracts of coral reef along the coasts but of raised beaches at a considerable distance and elevation inland, containing shells similar to those of the adjacent seas, that much of the archipelago has been heaved from below the sea-level within comparatively recent times."

"Volcanic forces have had a great share in shaping the archipelago, and a large number of mountains bear the stamp of their former activity."--Encyclopedia Britannica.

The Characteristic Oval Coastline of China.-- That portion of the stratum which moved westward but lacked the impetus necessary to carry it to the Tibetan plateau and westward, was forced up against the old Hindustan-Siberian continent as drift from the Pacific area. Elongated sections of surface strata moved southwestward toward the Asiatic coast and became attached to its most eastward projections. Under the reaction of coastward compressions, these additions rounded out the coastline of their respective sections into the characteristic China oval, with the arc of greatest curvature perpendicular to the

direction from which the strata came, as at u, v, w, Fig. 35.

Manchuria, China, and Siam have this characteristic coastline. Under the motion here presupposed, the northern islands of Japan would become attached to the eastward projection of the Manchurian coast, while its southern islands would be added to the most eastward section of the coast of China. This coastline of similar, approximately equal, oval sections is a phenomenon so unique and characteristic as to constitute convincing evidence of the correctness of these deductions with respect to its formation.

Borneo Reoriented.-- Of the oval sections in the coastline of Asia, Siam presents a figure of physical discontinuity which indicates a disruptive alteration of the characteristic features it developed when formed. Thus, above Siam there is a coastal indentation, D, the counterpart of those at E and F, Fig. 35. From each of these indentations the coastline extends southeastward in similar, characteristic, oval curves. In Manchuria and China the coastline is continued as an oval or ellipsoidal configuration to the next indentation, but in Siam it terminates abruptly in the square end, G.

The similarities in the physical and geological features of Siam and Borneo imply for these land divisions a related origin, while in the case of Borneo in comparison with the islands which surround it, dissimilarities indicate an unrelated origin. To reunite the island with the section of land of evident similarity of origin, and at the same time reconstruct Siam so as to restore its characteristic oval coastline, let Borneo be reoriented through 180° and moved up against Siam, as indicated in outline in Fig. 35.

The position of Borneo thus replaced, reveals the cause of its disruption from Siam and of its orientation and removal to its present position. The south end of the replaced Borneo lies athwart the lava tubes which extend from Tibet by way of Sumatra and Krakatoa to the South Pacific area. The implication is clear that Borneo was removed to its present position by the disruptive action of self-extending lava tubes in pushing their way southeastward toward the South Pacific area.

Corroborative Geological Data.-- A

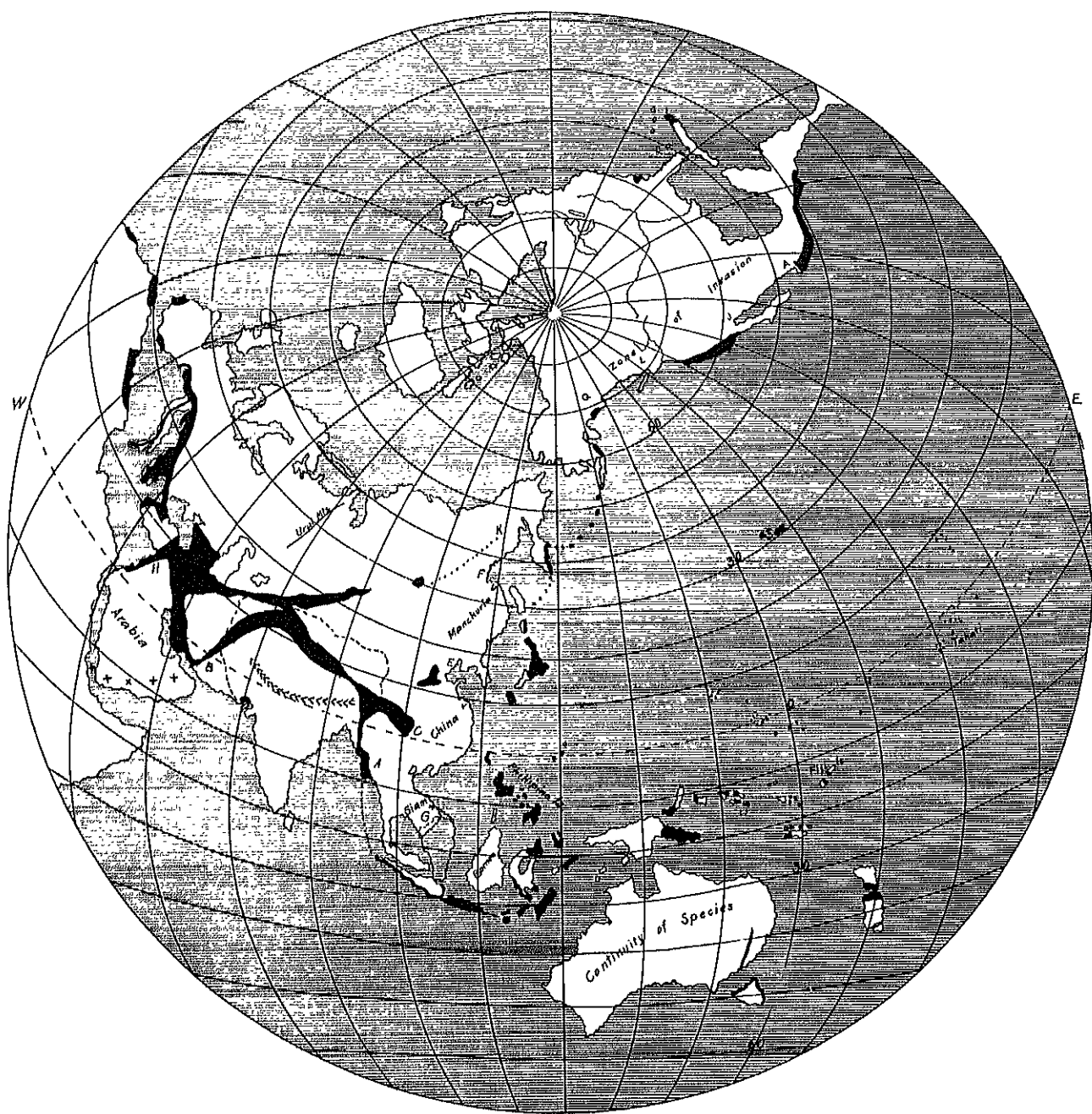


Fig. 35.— Earthquakes of Europe, Asia, and the Pacific Area

convincing amount of geological data might have been included in this discussion were it not for the circumstance that a logical development of the points under consideration might, thereby, have been interrupted. A recent publication with respect to the Asiatic region under consideration could profitably be included in full. The following brief quotation from it will indicate the manner in which its record of observed data support the implications of the discussion:

"The most important single structural feature is the unconformity between the folded strata of comparatively ancient formations, which together make up a complex oldrock floor, and the nearly flat-lying sediment of Cretaceous and younger age, which lie above this floor.

"Wherever the rocks of these two very different types of formations--the sedimentary cover and the floor--are seen in contact or where their structural relations can be determined, a great unconformity is found between them. The hiatus is so extensive that mountain-folding and erosion of thousands of feet of material were accomplished before the first basin sediments were laid down.

"Furthermore it appears that during this interval an entire change in the diastrophic habit of North Central Asia came about. Mountain-folding characterized the deformations that took place before that time, whereas warping and block-faulting without mountain-folding, characterized subsequent epochs.

"Late Mesozoic and Tertiary continental sediments carrying a remarkable new fauna constitute the formations developed above the non-conformity. The rocks below, representing together all the ages preceding the lower Cretaceous, form the floor immediately beneath the younger sediment, and constitute the present surface in other parts of the region."

Geology of Mongolia, by Charles P. Berkey, Chief Geologist and Frederick K. Morris, Geologist; Natural History of Central Asia, Vol. II, pages 288-9. Central Asiatic Expeditions; Roy Chapman Andrews, Leader.

8. The Original North Pole

The removal of the surface stratum from the Pacific area and its deposition

across the continent of Asia will have so changed the dynamic status of the earth, that its present axis will not be its original axis of rotation. A further consideration of the movement of surface stratum in the northern hemisphere requires that the original axis, in particular the original north pole, be located. There are a great number of independent criteria for locating the original pole, and the question arises as to which will give its position most simply and exactly. The method adopted has been to locate the original pole by one of these criteria and permit the others to appear as corroborative evidence of its correctness, when the phenomena with which they are concerned are under consideration.

Located by the Himalaya Mountains.--

When the continental segments, Hindustan and Siberia, moved out of their respective hemispheres toward each other, as represented in Fig. 34, the meridian forces, (M), actuating their movement became zero at the equator. Hence the mountains erected at their common boundary were on the equator. The position of the original north pole, therefore, is 90° north of the Himalaya Mountains. The point thus located is situated in the North American continent on the western margin of Hudson Bay, 28° from the present pole. To show the relationship of surface phenomena to the original pole, as in Fig. 35 and 36, terrestrial spherical coördinates have been drawn with respect to the original axis. From this transformation of the earth's coördinates, simple, straightforward, and adequate explanations of many observed phenomena of geology can be made.

The Warm Climate of Siberia.-- A point in Siberia 58°, north latitude, as represented in Fig. 33, is a region of frigid climate where perpetual frost exists at a short distance below the surface. The same region as represented in Fig. 35 and 36, with a north latitude 30°, was one having a tropical climate. Geology supplies abundant evidence that, at a former epoch, northern Siberia was a region of mild climate teeming with tropical life, both of plants and of animals. An alteration in the position of the axis of rotation, brought about by the redistribution of the earth's surface stratum, accounts for the former tropical climate of Siberia in contrast with its present frigid climate.

The Continent of Europe.-- From the

manner in which the earth developed, as implied in Fig. 34, it is evident that an unbroken surface stratum once covered the north pole and extended to lower latitudes. Of this original stratum only that forming the North American continent remains. That which formed Siberia moved southward to meet Hindustan, while the stratum which composed the Pacific area was transported to Asia. The stratum which occupied the area north and east of Labrador, therefore, has moved southward with respect to the original pole and now constitutes the European area, which occupies the region bounded by the Ural Mountains and Caspian Sea on the east and by the Mediterranean Sea on the south.

Greenland, Norway, Sweden, and England may be regarded as typical of the size and shape of the units of surface stratum which broke away from the north polar cap and, with respect to the original pole, moved southward along their respective meridians. As moving sections of the invading stratum were forced against the old Hindustan-Siberian continent, of ancient formation, the Ural Mountains were formed, and as other sections were compressed toward Africa and Arabia, the Alps and Apennine Mountains were erected.

To reconstruct the northeastern section of the polar area, move Labrador into the Hudson Bay with its ice center adjacent to the one at the pole. Return the small islands above the continent of North America to their former juxtapositions and follow them with Greenland, Norway, Sweden, and the other European areas in consecutive order. To restore Labrador to its former position the New England States would have to be moved northwestward or, more correctly stated, the Appalachian range would have to be unfolded.

The North American Ice Sheet.-- It is in complete conformity with expectation to find that an ice sheet once covered the continuous stratum surrounding the original north pole. The apparent ice center in Labrador is eliminated as a separate entity by merging it with the one at the pole as the peninsula is restored to Hudson Bay. When the movement began by which Labrador was separated from the western shore of Hudson Bay, a crevasse was formed at their boundary of separation which extended downward to the sub-surface solid. The rapid conversion of ice into steam within the

cauldron formed inaugurated a movement of Labrador ice toward it, thus giving rise to the apparent ice center in the peninsula.

The European area which exhibits ice lines acquired them while its surface blocks were parts of the continuous stratum surrounding the pole. The different surface sections, on moving southward, carried upon their respective surfaces the evidence of the effects of reactions to which they had been subject as integral parts of the polar stratum within the zone of ice reaction. Replacing these sections of surface stratum to their former positions would shorten the ice lines of Europe so as to make them equal in length to those of Missouri or Ohio.

The Cordillera Ice Center.-- A detailed examination of ice lines brings to light many significant implications with respect to the movement of the surface blocks upon which they are impressed. Of these, no group is of greater interest than the ice lines associated with the Cordillera ice center as shown in Fig. 33. The implication of the Cordillera ice lines is that the surface blocks of the region were afloat, and that a crevasse opened up along the line, LQ, and extended downward to the stratum of lava which upbore them. The crevasse thus became a great cauldron for the rapid conversion of the ice, moving into it from both sides, into steam. The array of arrows on either side of the line--one group pointing east, the other west toward it--is convincing evidence of the presence and activity of this steam-producing cauldron.

The ice lines pointing north at Q indicate that a continuous land connection was maintained at the north end of the crevasse, while the continuity of lines at L establishes the fact that no separation occurred at the south end. During the period of ice activity the crevasse became filled with glacial drift and surface debris, matter easily convertible into lava. With the removal of the ice sheet and a return of the attached section west of the crevasse to its former dynamic status, the matter that had been carried into the cauldron was converted into lava through the horizontal compression to which it was then subjected. The extensive lava flows in Oregon, Washington, and Idaho, of observational record, were evidently derived

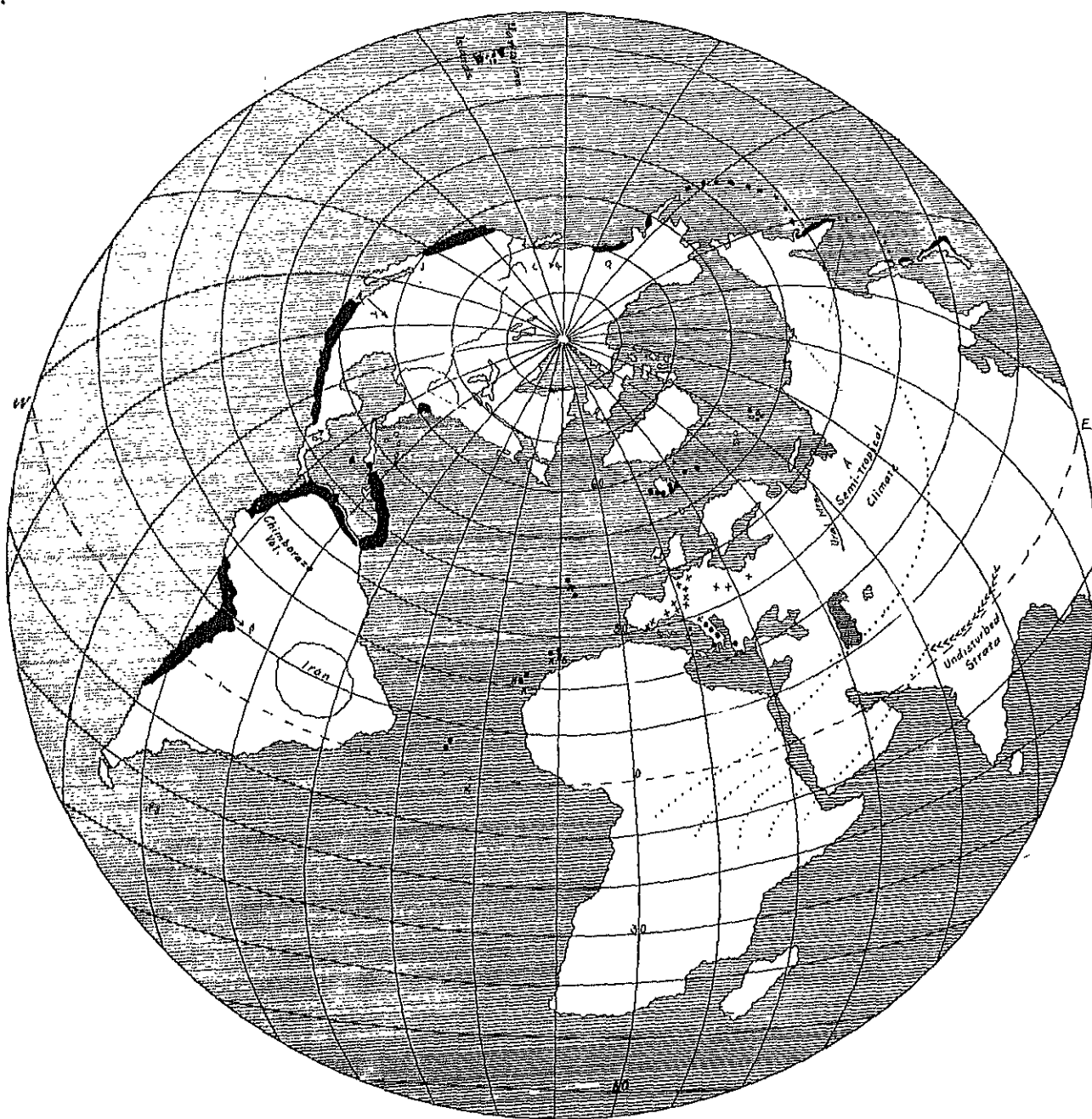


Fig. 36.— (a) Terrestrial Coördinates Referred to the Original Pole
 (b) Volcanoes of Europe
 (c) Earthquakes of the Pacific Coast

from this source.

It may thus be said of the north polar ice sheet that, originally, it was a continuous surface stratum with a single ice center at the original north pole. Its normal southward extensions are represented by the distances along meridians from the original pole to the marginal rivers; namely, the Ohio, the Missouri, and the Columbia River. On account of the earth's eruptive activities, there were periods when a rapid deposition of polar ice occurred that resulted in the southward extension of the ice margin. During a period of no eruption, when ice precipitation was at a minimum, the ice margin receded poleward. In a representation of the completely restored ice cap, the ice lines to the Atlantic States would be slightly shortened because of the changes wrought by restoring Labrador to Hudson Bay.

Volcanoes and Earthquakes in the Pole-to-Europe Motion.-- Greenland is an outstanding example of a surface block stranded in mid-career in its meridian motion toward the equator. The formation of a crevasse incident to the separation of a surface block from the mainland would inaugurate a rapid cooling process which would tend to stop the motion and attach the margins of the block to the sub-surface solid. Obviously, Greenland has attained to this situation. That it is of a lava-producing elevation is attested by the active volcanoes of the surrounding region, in particular, those of Iceland and by those which extend southward to the north coast of Africa, as shown in Fig. 36. The implication is that submerged lava tubes extend from Greenland to these regions of volcanic activity.

The countries of Europe have likewise been subject to volcanoes and lava flows in recent geological time which fully attest to motions similar to those of Greenland. The evidence of a continuity of land connections intermittently established by lava tubes between North America and the surface blocks moving toward the equator is found in the geological records of Europe in comparison with those of North America.

The recently active volcanoes of Middle Europe, taken as a unit, have a longitudinal extension along the same parallel of latitude with respect to the original pole. The lava flows which their

presence implies were induced by horizontal compressions as outlying blocks pressed southward toward the equator. The Alps and Apennine Mountains were pushed upward under the reaction of this equatorward compression. The present inactivity of the volcanoes of Middle Europe implies that the surface stratum here has become organized and reinforced against a further flow from the stratum of lava which underlies and supports it.

The earthquake region of southern Europe, Fig. 35, represents the line of contact between the invading stratum of Europe and that derived from the southern hemisphere, supplemented by that from the Pacific area which may have invaded this region. The blocks which form the surface stratum of southern Europe, afloat as they are on a stratum of lava, move in reaction to varying forces superinduced by changing conditions of lava pressure.

The Moon's Orbit in Relation to the Original Axis of Rotation.-- Particles from the earth projected eastward in the plane of the earth's equator, and in planes parallel to it, were eventually drawn together under the force of their mutual gravitations to form the moon. The earth's original axis, therefore, must have been perpendicular to the plane of the moon's orbit.

The earth's original axis has an inclination of 28° to the present axis and intersects it at the center of the earth. As a consequence of the earth's axial rotation, the original axis revolves about the present axis once in 24 hours. When the moon's declination is -28° , the original axis, in describing its diurnal revolution, is brought to the position in which it is perpendicular to the plane of the moon's orbit. Were rotation on the original axis resumed at the moment of its perpendicularity to the plane of the moon's orbit, the original state of rotation of the earth would be restored.

In this position, since the plane of the moon's orbit has an inclination of 5° to the plane of the ecliptic, the original axis would have had an inclination of 5° from perpendicularity to the plane of the ecliptic instead of $23\frac{1}{2}^{\circ}$, as of the present axis. The earth under this original state of rotation had distinct latitude zones of climate with very slight, if

any, seasonal changes. There would have been, therefore, no seasonal advance and recession of the polar ice caps such as now occurs on the earth between winter and summer. The only way in which the polar ice could melt was to be heaped so high at the poles that the resulting hydrostatic pressure forced the lower strata of ice to flow southward along meridians into the zones of milder climate. This state of the earth's rotation, therefore, accounts for the ice lines radiating from the original pole, for the zone of maximum erosion surrounding it, and for the rivers whose sources were in the marginal regions of the ice cap.

The Earth's Magnetic Axis in Relation to the Original Axis.-- The erupting columns of electrified particles projected eastward in planes parallel to the earth's equator will have magnetized the atomic elements of the centroid so that, in summation, their magnetization determines the magnetic axis of the earth. In this case the original axis of rotation should have coincided with the earth's magnetic axis, and since it is unlikely that any demagnetization process has intervened to alter the relationship, the two should be in very approximate coincidence today.

It is significant in this connection, therefore, that the earth's magnetic north pole has the same terrestrial longitude as the original pole and a latitude but a few degrees from it. Lines of equal dip and magnetic intensity undergo significantly rapid changes in curvature and distribution at the original pole, the implication of which for the problem in hand is that the two axes are closely coincident. The near approach to coincidence of the original pole with the earth's north magnetic pole is of undoubted significance toward a verification of the implications drawn with respect to the earth's magnetization.

10. The Sub-surface Eruption on the Earth

The Great Lakes of the North American Continent.-- Of all geological phenomena none presents more convincing evidence of the reaction of tremendous forces on the earth than do the excavations which constitute the Great Lakes of North America. To visualize the activity, the following data will be of use.

From these data it will be seen that the Great Lakes, with one exception, have depths with respect to sea-level

Lake	Area in Sq. Mi.	Above Sea-level	Surface Depth	Sea-level Depth
Superior	32,000	600 ft.	900 ft.	300 ft. below
Huron	23,000	574	800	226 "
Michigan	22,400	578	1000	422 "
Erie	10,000	564	90	474 above
Ontario	6,700	234	412	178 below
Total Area	94,100			

State	Area
Maine	33,040 Sq. Mi.
New Hampshire	9,340
Vermont	9,564
Massachusetts	8,266
Rhode Island	1,247
Connecticut	4,965
$\frac{3}{8}$ of New York	27,677
Total Area	94,100

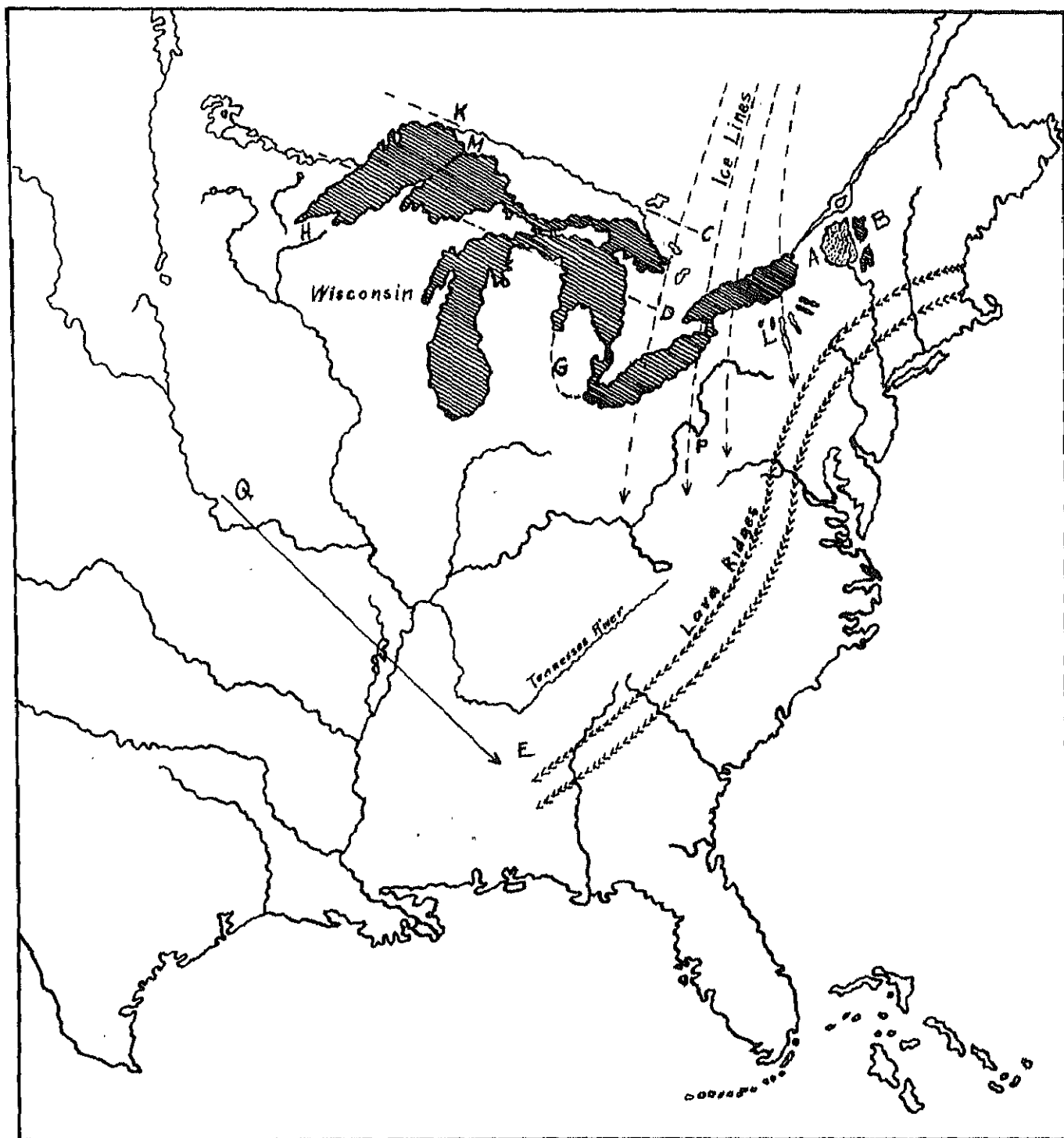


Fig. 37.— Deposition and Mountain-folding



Fig. 37:D.-- Mountain-folding

which do not differ greatly from a mean value of about 280 feet. Beyond doubt, Lake Erie was originally an excavation having a sea-level depth of about 200 feet. In surface area and dimensions it is a near duplicate of Lake Ontario--a relationship which implies a recurrence in equivalent excavating efficiency of the activity which gave the companion lake its depth below sea-level. While the other lakes retained their original depths in considerable measure, the advancing ice sheet filled the original excavation of Lake Erie to its present surface depth of 90 feet by pushing into it disintegrated surface material which had been superimposed north of the lake.

Physical and Dimensional Features of the Great Lakes.-- The distance from the western tip of Lake Superior to the eastern shore of Lake Ontario is 800+ miles, and from the north shore of Lake Superior to the south shore of Lake Michigan it is 500+ miles. The excavation accomplished was the removal of surface material equivalent in amount to a block having a surface area of 94,100 square miles and a depth of 580 feet, of which about 300 feet was below sea-level. The area, it may be noted, is equal to that of the New England states with $\frac{3}{5}$ of New York included.

Although the lakes are within the area of the ice zone of the original pole, the physical characteristics of advancing ice preclude the possibility of ice having been the instrumentality of their formation. The only way in which advancing ice could form a lake would be to have placed in front of it a block of hard material which it could push along, and the process would require more excavating blocks by far than the material excavated. The subject might be closed by designating the excavating blocks, "glacial drift", without accounting for its origin, and presupposing that the blocks were present in polar ice in sufficient quantity to excavate 94,000 square miles of territory on one side of the pole to a depth of 580 feet. As a matter of fact, any surface feature, as a lake, should have its longest axis parallel to the ice lines, if a motion of the ice produced it. No such orientation exists with respect to any of the Great Lakes, although they have elongations which cannot be without significance respecting their

origins. So great a phenomenon as this group of lakes would not have been discontinued at Lake Superior if ice emanating from the original pole produced it. A consecutive series of great lakes at a uniform distance from the original pole would, in that event, be anticipated.

Despite the circumstance that no evidence is found to indicate a physical connection between the ice sheet and the activity by which the lakes were formed, there is abundant evidence of its activity in moving forward the materials scooped out of them.

The Guttenburg Reaction on the Earth.-- By this heading reference is made to the reactions discussed with respect to the formation of the lunar crater, Guttenburg. Since each of the Great Lakes possesses physical features and dynamic relations which imply an origin similar to that of this crater, the photographs of that discussion, Fig. 24 and 26, may be considered as representing conditions analogous to those on the earth.

Lake Ontario is 5 times greater in length than in breadth. Northeast of the lake in exact alignment with its longest axis are the Adirondack Mountains, A, Fig. 37, whose geological status is that of a disorganized heap of disrupted surface strata with predominant outcroppings of old rock structure. So recent is the formation of this lake, with the consequent erection of the mountains at the end of it, that the advancing ice sheet had become ineffective as an agency for pushing before it the heap of disorganized surface blocks thrown across its line of advance. As a consequence, the relationship of the excavation to the material scooped out of it, without the intervening action of ice to obliterate it, is preserved to geology in the relationship of Lake Ontario to the Adirondack Mountains.

Lake Erie is strikingly similar to Lake Ontario in outline, surface area, elongation, and in the orientation of its longitudinal axis. When evidence is sought for, northeast of Lake Erie, with respect to a quantity of excavated material in the position of a relationship similar to that of the Adirondack Mountains to Lake Ontario, there is found instead the beginnings of long narrow lakes, L, with their longitudinal axes radiating southward in directions coincident with the ice lines at

the point. Along the way in the zone of the lakes, L, there is an inarticulated mass of surface strata with frequent outcroppings of oldrock structure. The implication is clear that before Lake Ontario was formed, the heap of excavated material from Lake Erie was pushed forward by the advancing ice into the region south of it, where it left surface markings characteristic of its southward movement.

Lake Erie and Lake Ontario, obviously, were each formed by an erupting column which descended to the surface of the earth at an acute westward angle of inclination. The vertical downward component of velocity of each erupting column gave the lakes their depth and the forward tangential component, their length. Their similarity to the Guttenburg crater on the moon is obvious.

The northwestern end of Lake Superior, section HK, Fig. 37, is similar to Lake Erie and Lake Ontario in approximate area, contour, and length, and in the orientation of its longitudinal axis. It will be observed, in particular, that the northwestern shore line of Lake Superior is parallel to the longitudinal axis of these two lakes and approximately equal to them in length. The implication is clear that HK is an excavation similar in origin to that of Lake Erie and Lake Ontario, and that the activity in its formation was confined to the contour whose northeastern boundary is represented by the line, M.

The longitudinal axis of each of these excavations, taken as a pointer, indicates the position in the zone of eruptions from which the column originated that produced it. In Fig. 36, this point is indicated by the arrow, γ , to be in the Mexican zone of earthquake discontinuity of the Pacific coast. The arrow, δ , in an alignment parallel to the longitudinal axis of Lake Michigan and Lake Huron, indicates the point of origin of the erupting columns which produced them. The original outline of the southwestern shore of Lake Huron is indicated by the contour, G. The topography of the region clearly indicates that loose materials of the excavations were pushed into the south end of the lake by the ice whereby the original outline of its southwestern shore was changed.

The excavations most obscured by the invasion of disintegrated surface mate-

rial are those whose longitudinal axis is at right angles to the ice lines. Their hypothetical reconstruction, however, is supported by associated topographical and geological features. The surface reaction of the descending columns from α , Fig. 35, may be postulated as having taken place between the lines C and D in the direction, KC.

The Order of Excavation.-- It is probable that the excavating activity in the zone of the Great Lakes began with Lake Superior and by a general eastward progression ended with Lake Ontario. Eruptions would occur successively in the three zones, α , γ , δ , because of accruing potentials. This order corresponds to the progression of the sun-spot activity from higher latitudes toward the equator during a cycle, as exemplified by Maunder's chart. For these reasons, the order in which eruptions occurred to produce the Great Lakes excavations is postulated as indicated by the numbers in Fig. 38. The total number, (8), corresponds closely to the number of advances and recessions of the ice sheet, as derived from a geological analysis of the phenomenon.

A Sub-surface Distribution of Metals.-- From α there came a descending stream of fluid iron, from δ copper. It appears, therefore, that through the earth's electrical potential, metals undergo a sub-surface distribution along the zone of eruptions during a period of quiescence, from iron, whose magnetic properties would assemble it about the poles, to copper, whose ready admission of a current flow of electricity would cause it to collect near the equator.

An Extensive Flow of Metal Lavas.-- Though these excavations are great in total area and depth, they represent but a small fraction of the total stream volume of molten iron, copper, and other metal lavas that flowed into them. The erupting streams, after being deflected upward, emerged from their respective excavations and flowed across the eastern section of the United States to the Atlantic seaboard.

At the inception of the activity there were no folded hills, now represented by the Appalachian system, to interfere with the direct flow of this metal lava to the coast. It overspread the plains of New York, Pennsylvania, and New Jersey, with its western margin extended to Western

Pennsylvania, Ohio, and West Virginia where some portions of the cooling mass were pocketed to become the iron mines of these sections today.

The flow of this metal lava across the Lake Ontario region carried away about 350 feet of surface material, as represented by the difference in surface elevation between Lake Ontario and the other Great Lakes. By implication, the region between Lake Ontario and the coast suffered a like denudation. The cooling mass left a rich deposit of iron in New Jersey, and formed an efficient metal barrier off the Atlantic coast amalgamated to the sub-surface solid.

A Former Invasion of Metal Lavas.--

An intrusion of erupting columns similar to that of the Great Lakes is indicated along the line, QE, Fig. 37, in the Missouri-Tennessee-Alabama region. The right-angled, northward deflection of the Tennessee River at E, with its northwestward flow to empty into the Ohio River, is a significant geological phenomenon. From the topography of the Appalachian Mountains, the Tennessee River would be expected to flow southwestward with an increasing downward slope into the Mississippi River whereas it flows in nearly the opposite direction. The implication is clear that an erupting column of iron lava from the α -zone of eruptions erected here an obstructing wall whose margin the Tennessee River followed northward to the Ohio River.

Iron in abundance is found along the line of this invasion from Missouri to Alabama, and the strata of the region in which the iron is found are in such a state of disruption as to indicate that some great movement

occurred at the time of its deposition. That the erupting columns of other metal lavas were, at the same time, directed to this region is confirmed by the presence here of copper, lead, and zinc.

The advent of the erupting columns converted the region into an extensive inland lake, according to geological records, but erosion reestablished old waterways, and the lakes were drained. A drainage of the Great Lakes is in progress which will lower their levels in a similar manner, and possibly return the region to its former system of drainage.

The surface flow of lava to the Atlantic Seaboard from the Alabama region resulted in the erection of an off-shore, metal barrier amalgamated to the sub-surface solid. It now underlies the Florida peninsula whose longitudinal axis, it will be observed, is a continuation of the line of invasion, QE,

A Long Continuity of the North Polar Cap.-- The evidence showing that the north polar zone of surface stratum with

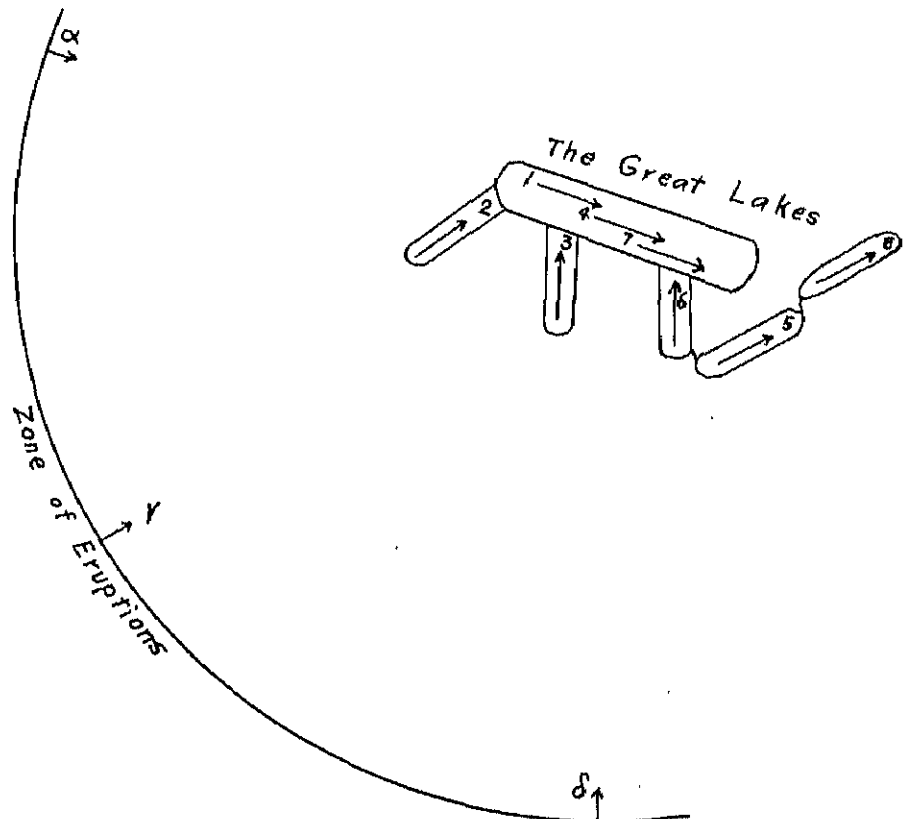


Fig. 38.-- Order of Excavation

its superimposed ice sheet remained intact throughout a considerable portion of the epoch of eruptive activity, during which the Great Lakes were formed, is found in the ice lines associated with them. Throughout most of the period the earth rotated on its original axis, Labrador occupied the Hudson Bay area, and the European blocks retained their original positions in the polar zone.

During the period of the activity an effective barrier of solidified metal lavas was erected off the Atlantic coast from Maine to Maryland. When the polar cap began to disintegrate in the latter part of the epoch and the European blocks to move toward the equator, the barrier thus erected halted Labrador in its motion and prevented a disintegration and a like equatorward migration of the eastern section of the United States. Thereafter, the horizontal compression to which the surface stratum adjacent to the barrier was subject as outlying blocks, including Labrador, pressed toward it, converted the Atlantic Plain into a succession of lava ridges as represented in Fig. 37.

This section of the north polar cap has thus attained the status of mountain-folding. Should the barrier along the Atlantic coast give way and the blocks forming the surface homeoid of the eastern states move along meridians toward the equator, it could confidently be predicted that an entire change in the diastrophic habit of the eastern states would take place. Mountain-folding which had characterized the deformations to the present time would cease, and warping and block-faulting without mountain-folding would characterize subsequent epochs.

The outlet of the lava tubes associated with the Appalachian lava ridges is by way of the Carolina coast and West Indies to South America. The earthquake region of the Carolina coast and the sequence of volcanic and earthquake activities extending by way of the western Antilles to South America clearly confirm the implication that the Appalachian system is the source of the lava flows which produce them. The implication is that an intermittent land connection between North America and South America has been maintained by the activity of lava tubes whose origin is within the North American continent. Geological observations furnish cor-

roborative evidence with respect to this deduction, as implied in the following quotation:

"The fossils of the West Indies are important, as from many of them clear evidence is obtained to show that at no very remote geological period the islands formed part of the adjoining continents. The remains of the megatherium, mylodon, and cabylara, essentially South American, are also found in North America, but only along the seaboard of Georgia and Carolina. As these are also found in some of the West India islands, as well as in South America, it is thus perfectly clear that at one time the archipelago formed a land passage between the two great divisions of the New World."--Encyclopedia Britannica.

The Extent of the Lava Ridges.-- When the lava ridges were formed they extended in a continuous sequence from the Atlantic coast to the region north of the Gulf of Mexico designated E, Fig. 37. The agency by which they were cut transversely to form the Connecticut, the Hudson, the Delaware, and the Susquehanna rivers was the metal lavas which required an outlet from the region of the Great Lakes to the Atlantic seaboard. It is evident that the St. Lawrence River channel also was determined by the flows of lava from this region. The valleys found in the ocean floor as continuations of these river channels were carved out by the streams of metal lavas which the rivers poured into them. The Green Mountains of Vermont and the White Mountains of New Hampshire are cross sections of lava ridges whose continuity was interrupted by a transverse flow of metal lava. The exposed headlands of these mountains afford mute evidence of the mountain-folding to which they were once subject, and the great boulders of their steep slopes bear out the implication of a continuity interrupted.

The Significance of the Adirondack Mountains.-- The heap of disintegrated surface strata, the Adirondack Mountains, was a much larger pile at its inception than at present. Originally, it extended toward the St. Lawrence River and overspread Lake Champlain and Lake George, E, Fig. 37. The high temperature that developed within the pile produced a disintegrating reaction in the surface strata upon which the eastern half of the original

heap rested, such as resulted in the formation of the Lake Champlain and Lake George depressions. As the flood of iron lava overspread the region of the Adirondack Mountains, sections of the eastern half of the heap were carried down the Hudson River as far as Long Island Sound. Outcroppings of oldrock structure along the Hudson and in lower New York confirm the implication of this translation. Long Island itself is a heap of this oldrock material in all probability, and the Thousand Island section of the St. Lawrence River is made up similarly of materials from the original Adirondack pile.

The Transportation of Surface Material.-- Each erupting column drew into its vortex a great quantity of surface material--land and ocean deposits and ocean waters--and this formed a sheath for its electrified metallic core. The matter composing the sheath attained a wider distribution upon deposition than the metal lava stream at the center, and its abrading effect upon the earth's surface was much less pronounced. Nevertheless, definite surface features in the region of the Great Lakes bear out the inference of its presence. For example, the succession of lakes northwest of Lake Superior, including Lake Winnipeg, are in alignment with the direction from which the α -eruption is presumed to have come, and their longitudinal axes coincide in some measure with that direction. The counterpart of these lakes is found in Fig. 25, in which indentations on the moon's surface are shown in alignment with respect to their presumed points of origin. Small masses, finely divided matter, and ocean waters were carried high into the earth's atmosphere and beyond it, where the waterdrops were congealed into salt water ice. This mixture added to the polar cap by precipitation at each eruptive activity accounts in part for the glacial drift of the polar ice sheet and for its periodic advance and subsequent recession. The extensive inland salt deposits found in the regions through which the drainage of the melting ice margin must have taken place certify to the implication that depositions of salt water ice occurred in the polar zone.

The sheath of surface matter transported with the erupting column is the source of many deposits which are in notable unconformity with the strata of the

region where they are found. The chalk deposits of Wisconsin, for example, which contain fossils native to deep sea areas in a tropical climate, were transported from the δ zone of eruptions. Wisconsin, by this explanation, is relieved of ever having attained a great depth below sea-level far removed from land, or a tropical climate conducive to the growth and deposition of fossils whose natural habitat is the equatorial zone. The first condition is dynamically impossible to the continental position of Wisconsin, the second, physically impossible to her position in latitude.

This explanation relieves geology of the fallacious deduction that ascribes to the earth at certain past epochs the impossible physical state of a uniform tropical climate over the whole earth. The deduction is based on the presupposition of a local development of fossils whose propagation is possible only in the ocean beds of tropical climates and whose distribution seems at times to have been universal. If the historical geologist abides by this assumption, he is under obligation to explain what factors operated to change the physical laws which now hold, relative to the distribution in latitude of the radiations received from the sun. Under the implications of the present hypothesis, the ocean waters containing these fossils were drawn into the vortex of erupting columns and given earth-wide distribution and eventual deposition.

The zone to undergo the greatest invasion of ocean waters and to receive a great deposition of disintegrated surface material is that immediately east of the zone of eruptions, Fig. 35. Its counterpart, due to a like cause on the moon, is shown in Fig. 24. The successive invasions of the sea in western North America, with extensive depositions of marine fossils and disintegrated surface materials, were accomplished by sub-surface eruptions whose streams transported the matter from the Pacific area. Some of the invasions of geological record, undoubtedly, are phenomena associated with the activities through which the Great Lakes were formed. The assumption of historical geology, therefore, that a marine fossil determines the elevation with respect to sea level at which depositions are made regardless of earth dynamics, geographical position, and

climate is fundamentally in error.

Radio-activity and the Age of the Earth.-- Atoms of metals undergo disintegration in their natural sub-surface positions within the outer homeoid of the earth where they are subject to external potentials which exceed those of the atoms themselves. When the metals are transferred to the surface and are no longer subject to the high potentials of their former sub-surface positions, the disintegrations of their atoms cease. The radio-activity observed in metals at the surface of the earth is a vanishing residuum of what it was in the homeoid of their natural positions within the earth. The reason why the radio-activity of metals may not be accelerated in the physical laboratory is the feebleness of the disintegrating potentials which the physicist is able to impose in comparison with the sub-surface potentials to which they have already been subject. In order to induce accelerations in their radio-active disintegrations, it would be necessary to submit the metals to higher potentials than those which they have endured.

These considerations confirm the implication that the isotopes of metals which have attained different stages of atomic disintegration did so at a rapid rate under the high potentials of their natural sub-surface positions. When the metals were transferred by sub-surface eruptions to the surface positions where found, their atomic disintegrations had very nearly ceased. Hence, the assumption that the rate of the disintegration of metals into isotopes has continued for billions of years, at the rate they are found to have at the earth's surface, is without foundation in fact, and the age of the earth based upon it must be entirely misleading. In any case, an extrapolation for so great a period on the basis of a doubtful assumption can have little value as representing the actual age of the earth.

9. The Disintegration Peculiar to the South Polar Zone

Erupting Columns Less Penetrating.--

The erupting columns of the northern hemisphere were actuated by an excess of electrons which the metal lava streams con-

tained, those of the southern hemisphere by an excess of protons. The proton streams were less destructive in their reaction on the surface stratum of the south polar zone than the electron streams were on that of the northern zone. Instead of disintegrating into small segments or losing much of its original structure through conversion into lava, the stratum of the south pole zone separated into large triangular sections which moved along meridians toward the equator.

During the epoch under consideration, the erupting columns in the mean position of the arrow, β , Fig. 36, projected streams of iron lava across the Andes Mountains where in its descent the lava spread out into an expanding heap to form the highlands of Brazil and produce the greatest deposit of iron in the world. At the same time, erupting columns brought other metal lavas to the surface in the southern zone of eruptions, as is evident from the abundance of metal deposits in the western highlands of South America. The upper arcs of these erupting columns of the southern hemisphere, it may be noted, were the counterparts of the great red spot in the southern hemisphere of Jupiter as shown at B, Fig. 19.

The reactions to the sub-surface eruptions resulted in separating Australia from South America and in pushing it westward as a unit toward southeastern Asia. That these two divisions of land were adjacent and in contact with each other at an earlier epoch, or were adjoined by intervening lava islands and ridges, is attested by Silurian deposits of a species peculiar exclusively to the two continents.

The Reconstruction of the South Polar Cap.-- To reassemble the sections of surface stratum which formed the unbroken surface of the south polar zone, move Australia toward South America, then remove all the triangular continents--Australia, South America, Africa, and Hindustan--toward the south pole. The sections thus reassembled are shown in Fig. 39, where they exhibit related contours which confirm the implication that this was their original configuration in the south polar zone.

Australia adjoins South America with their adjacent coastlines in coincidence. The outline of the northern part of Hindustan, although hypothetical, is verified by the implications of the

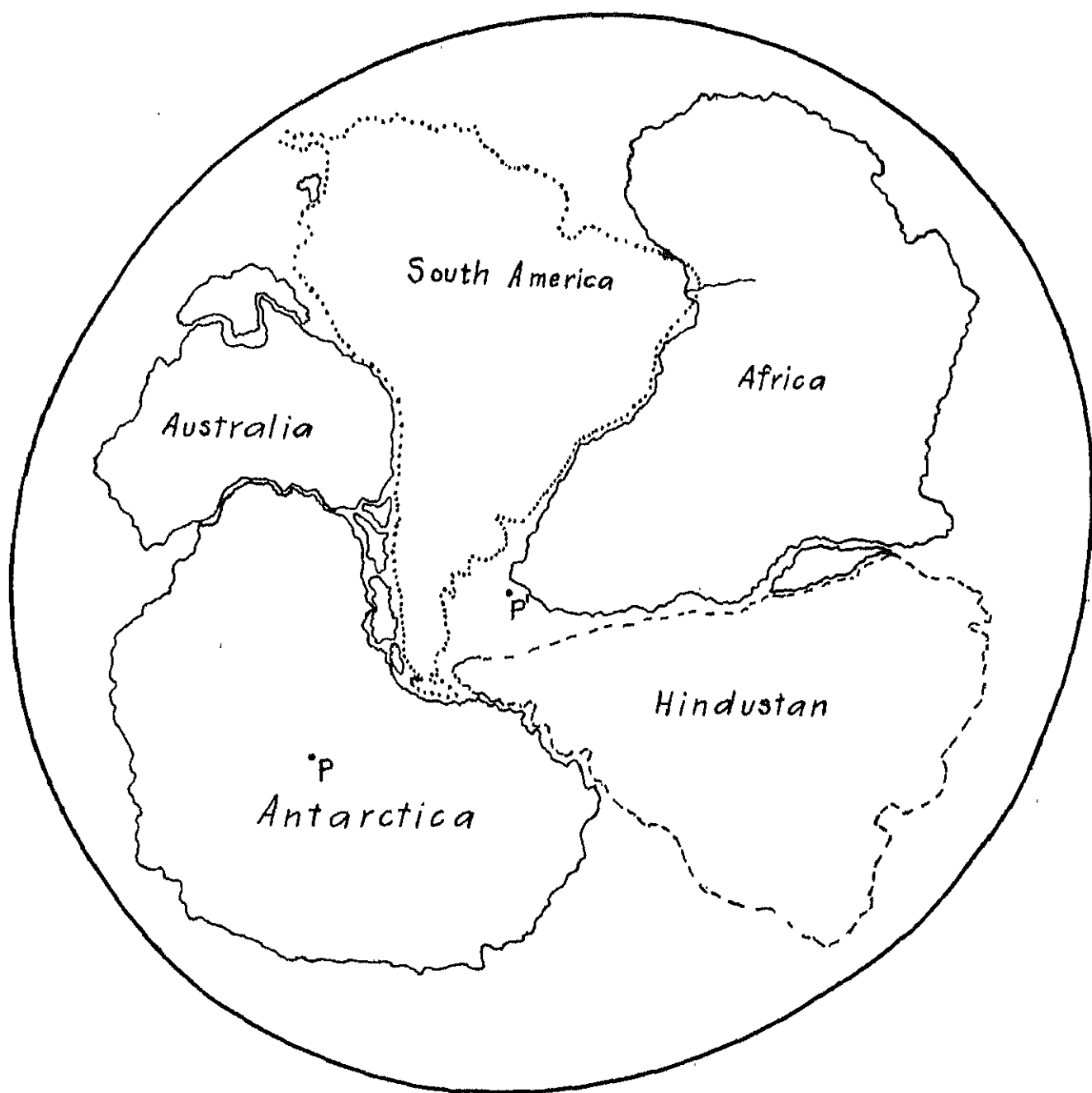


Fig. 39.— The South Polar Cap Reassembly

previous discussion. The original eastern coastline of Africa has been obscured by an invasion of surface stratum, so that a close coincidence with it may not be anticipated. The two coastlines that have suffered no obliterations are the eastern coastline of South America and the western of Africa. When the two continents are brought together, as in Fig. 39, a remarkably exact coincidence is found between their adjacent coastlines; for 2,500 miles the indentations of one are the exact counterparts of the projections in the other. The probability that this relationship is one of mere chance is very remote. The phenomenon constitutes convincing evidence of the correctness of the deduction with respect to the reassembly of the continental sections of the south polar zone as here represented.

That this reassembly represents the actual relative positions occupied by the continents at an earlier epoch is confirmed by a comparative study of their fossils. These indicate, in general, that at an early epoch land connections between the four continents insured a common development of plants and animals. Subsequent isolation permitted evolutions peculiar to the physical characteristics of each continent in its altered geographical position. Where the equatorward-moving continent eventually made contacts across the equatorial zone, remarkable new forms of plant and animal life made their appearance, as in Hindustan, Africa, and South America. The remaining continental section moving southwestward, with no contacts across the equator, retained a continuity in the development of its plants and animals peculiarly Australian.

The land life of Australia has not been subject to sudden terminations by overwhelming depositions as has that of North America. Australia occupies a geographical position protected against the destructive effects of sub-surface eruptions; North America, a position directly exposed to them. The renewal of land life in North America after a sub-surface eruption has been, essentially, by invasion rather than by survival.

The Original South Pole.— During the period of this surface movement of continents toward the equator the earth's axis of rotation shifted in such a manner that the south pole underwent a change of about 28° in latitude—from P' to P , as represented in Fig. 39. This alteration placed the south pole near the center of mass of the ice-covered section of surface stratum remaining, and thus increased its stability. In this way the Antarctic continent with its great deposit of ice is accounted for.

The implications of the Hypothesis of Eruptions with respect to geology might have been discussed in greater and more convincing detail than that here presented. The purpose of the discussion, however, was not primarily to develop an hypothesis that should fit the earth's evolution but to show that the sub-surface eruption has been an important factor in determining the dynamic status of the earth as a celestial body that has been subject to reactions whose counterparts may be observed today in the sun, the major planets, and the stars.

CHAPTER VI

THE STARS

1. Stars in Eruption

The Sources of Stellar Luminosity.--

The sun, Jupiter, Saturn, the moon, and the earth exemplify the activities of a celestial body in different stages of development. The sun is studied as a typical star, and the major planets, the moon, and the earth may be regarded as stars in miniature. To know what is taking place, relatively, within stars in stages of development similar to those of the planetary bodies, it will be necessary to presume their manifestations magnified to stellar dimensions. From a state of many eruptions both north and south of the equator, as in the sun, there will develop the condition, as observed in the planets, of a decreasing number of separate eruptions as the tenacity of the surface shell increases; in other words, as the relative quantity of de-electrified matter in the configuration becomes excessive. Eventually, the star's eruptive forces will be concentrated into one major erupting column whose reaction will maintain an aperture in the surface homeoid for the emergence of its electrified particles. In this stage of development, the star's brightness will reside, in appreciable measure, in the momentary luminosity of its single erupting column as presented to the observer by a rotating celestial body.

A Changing Orientation.-- Given a star in single-column eruption observed from a fixed point in space, its rotation will produce a continuous change in the direction of projection of the erupting column. At a certain position in the star's axial rotation, the direction of projection will be toward the observer if he is in the plane of the star's equator; half a period later it will be in the opposite direction. Under spectroscopic examination, light emanating from the erupting column will give rise to alternate shifts in the star's spectrum lines:

(1), toward the violet when the erupting column is directed toward the observer, and (2), toward the red half a period later when it is directed away from the observer.

The erupting column has a sheath of surface particles moving outward at a consistent speed, at the center of which there is a core of electrified particles moving at a higher speed. There will then be three sources of luminosity in a star in sub-surface eruption as follows:

(1), that from the core of electrified particles, (2), that from its enclosing sheath, and (3), that from the star's atmosphere. These three sources of luminosity are exemplified in the photograph of Jupiter, B, Fig. 19, at maximum eruptive activity.

Spectra of the Three Sources.--

Spectroscopic observations of the star, when the column is directed toward the observer, will yield a composite spectrum consisting of (1), a set of absorption lines from the sheath, indicating radial motion toward the observer, (2), a set of bright lines from the core indicating a still higher motion toward the observer, and (3) a group from the star's atmosphere indicating zero motion unless the star itself has a radial motion toward or away from the observer. When the column, by virtue of the star's rotation, points in the opposite direction, the spectrum will be of a composite type with the lines from the core and sheath of the erupting column indicating a motion away from the observer, with no change in position of the lines from the star's atmosphere.

These relationships are shown in Fig. 40, where the rotating star is represented with its north pole at N, its erupting column tangent to the star's surface at a, and its atmospheric envelope included within the outer circle. The arrow, A, may be regarded as representing the core of electrified particles, and the cylindrical configuration, S, as its enclosing

sheath. The direction from which the star is seen is marked, "Observer." In the relative positions represented, the core of particles will give the highest spectrographic velocity toward the observer, its enclosing sheath a lower velocity in the same direction, and its atmosphere one still lower and constant. The three sources of light will yield characteristic spectra: the core, a spectrum of particles in a state of the highest radiant energy potential; the enclosing sheath, a spectrum characteristic of matter in a lower state of radiation; and the star's atmosphere, one simulating that of the solar atmosphere.

Sequence with Respect to Source.--

Among the stars there will be a deviation in the dominating source of their respective radiant energies, from that in which the light emanates from an equalizing radiating shell, as in the sun with its erupting columns largely submerged, to that in which the radiating shell is depleted of its radiant energy to the extent that the star's brightness depends upon the momentary luminosity of its erupting column. If the stars be presumed to be arranged and observed in consecutive order, from those whose source of light is in their radiating shells to those whose luminosity is wholly that of their respective erupting columns, with those between having luminosities dependent in varying amounts upon the three sources, then characteristic differences will appear in the spectra of the stars, depending upon their respective positions in the sequence.

The first manifestation detectable along the sequence, of a change in source from the radiating shell to the erupting column, will be a shift of lines first to the blue and then to the red end of the spectrum coincident with the star's period of rotation. The number and strength of lines thus affected will increase as the source becomes more predominantly that of the erupting column, and in the final stars of the sequence their spectrum lines will exhibit shifts and indicate characteristics corresponding to the physical conditions and motions of particles in the core of their respective eruptive activities. To determine what the line shifts and spectrum characteristics will be when the light source is dominantly that of the erupting column, recourse is had to the

representation of a star in single column eruption, as represented in Fig. 40.

2. The Erupting Column the Source of Light

With Respect to the Figure.-- When the erupting column has the position of the arrow at A, pointing toward the observer, the source of his light from the star will be from a column of particles of a depth equal to the length of the erupting column, and having a depth of the star's atmosphere intervening, such as lies between him and the point of the arrow, A. When the star's rotation has carried the column to the position, C, so that it is perpendicular to the line of sight, the particles from which the observer's light comes will have a depth equal only to the diameter of the prostrate column, with its obscurity increased by its enclosing sheath and by a greater depth of stellar atmosphere intervening.

At B the column will again become a light source similar in depth to what it was at A but with its particles projected in a direction away from the observer and with its light subject to the extreme modification which a greater depth of stellar atmosphere intervening between the erupting column and the observer imposes. At D the erupting column passes into occultation and undergoes complete obscuration because of the intervening opaque body of the star.

Variations.-- Unless it retain a voluminous radiating shell, such a star will be one whose light varies in brightness. In stars such as are similarly affected at A and B by the intervening stellar atmosphere, regardless of its difference in depth respectively, or where the erupting column emerges above the atmospheric envelope in both positions, there will be two equal maxima corresponding to the positions A and B, with a secondary minimum halfway between them corresponding to the position, C, of the erupting column. The primary minimum will correspond to the column's complete occultation at D.

In case the greater depth of intervening stellar atmosphere at B absorbs the light of the erupting column in greater measure than at A, the second branch of the star's light curve will be suppressed in proportion to this differential

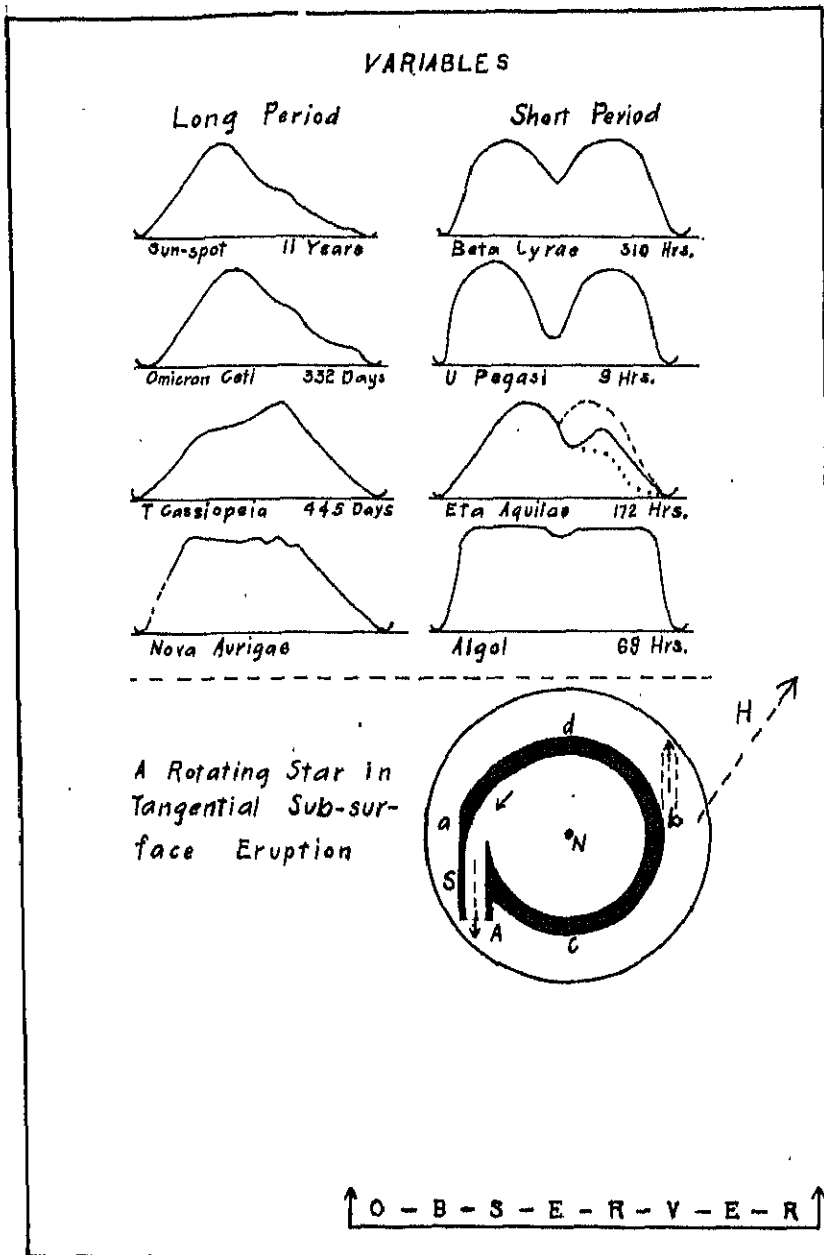


Fig. 40.-- Variations due to Sub-surface Eruptions

obscuration, as in Eta Aquilae. The position of the light curves in Fig. 40, above the figure representing the consecutive orientations of the erupting column, serves to visualize the conditions responsible for the variations in the light, velocity, and physical constitution which the stars exhibit.

There will be characteristic deviations in the spectra of some stars incident to the difference in depth of stellar atmosphere through which the observer sees the column at *a* and at *b*, respectively.

For example, the column at *a* may emerge to the extent of yielding a bright line spectrum, whereas at *b*, subject to heavy atmospheric absorption, it will give a spectrum of many dark lines.

Modifications Due to the Force Curve.-- The velocity of projection toward the observer from *a* and away from him at *b* will be made up of three superimposed velocities: (1), a constant velocity, that of the star through space; (2), a constant tangential component of velocity due to the star's rotation; and (3), a variable component of tangential velocity due to the star's eruptive cycle, whose counterpart is represented by the force of eruptions curve or, in more familiar terms, by the sun-spot curve.

On account of the variability of this latter component, (3), the recurring short period radial velocity values at *a* and *b* will undergo a cycle of changes in numerical magnitude which will be functions of the forces represented by ordinates of the force, or sun-spot, curve. Continued radial velocity determinations, therefore, will result in the derivation of the mean rotation period of the star and of its force of eruptions, or sun-spot, period.

Since the erupting column may not maintain a constant position with respect to the surface of the rotating body--no more than the red spot of Jupiter does with respect to the planet--but may move R-ward or D-ward irregularly, deviations of the short period values from equality may be anticipated.

The Epochs of Column Luminosity.-- When, in the process of giving up its kinetic energy as radiant energy, a star's erupting column becomes its dominant source of light, is a matter of interesting

speculation. It seems that there may be two periods: (1), when the star is in an early stage and (2), when it is in a late stage of development. Through both these periods it would lack the eruptive activity to supply electrified particles to the radiating shell at a rate sufficient to submerge its erupting columns and produce a constant radiation. Through middle age, with its erupting columns submerged, the star's brilliancy would be maintained by a voluminous replenishment. As it gives up its atomic energies as radiant energy, the star's brilliancy should increase to a maximum and then undergo continuous diminution.

Stellar Eruptive Cycles.-- The analysis of stellar variability on the basis of these deductions yields significant and interesting coördinations. A few cases of its applicability, merely to serve as examples, will be cited.

Capella has a composite spectrum; one set of lines is indistinguishable from the solar spectrum, while the other set is the spectrum of a light source of more intense radiation. The two sets of lines are in anticipated agreement with the physical relationships implied in these deductions, for they appear alternately on opposite sides of each other with their lines shifted in consecutive order to the blue, and to the red end of the spectrum. The condition confirms the implication of the reaction of the oppositely directed erupting column as it is brought successively to the positions, a and b, by the star's rotation. A result anticipated of these deductions, and not accounted for otherwise, is found in the observed irregularity of Capella's period. The implication, as in the variable period of Jupiter's great red spot, is that the star's erupting column is not maintaining a constant position with respect to the surface of the rotating star.

Polaris has a single type spectrum, as distinguished from a composite, which is similar in the distribution and relative strength of its lines to the more luminous group in Capella. By implication, the set of lines in Capella and that in Polaris have their origins in the core of their respective erupting columns. Other surface sources, obviously, are relatively too faint in Polaris to impress their lines on the spectrographic plate. As determined

from the periodic shift of the set of lines recorded, the axial rotation of the star carries its erupting column through a change in orientation of 360° , in four days. This, then, is the star's period of axial rotation.

The numerical magnitude of the radial velocity of Polaris varies in a consecutive order which is presumed to recur, one period following the other, in nearly equal intervals of time. The periodic recurrence of low and high radial velocity values in Polaris is a manifestation of the activity represented by the force of eruptions, or sun-spot curve. It is anticipated that the cycle of change in the star's radial velocity will be repeated, but in periods as variable as those of the sun-spot cycle and with deviations from the former values of the radial velocities throughout a cycle, as great as the deviations of the ordinates in successive cycles of the sun-spot curve. Recurring cycles approximately equal are anticipated of this phenomenon. Dr. Joseph H. Moore of the Lick Observatory gives 29 years as the period of a single cycle of change in the radial velocity values of Polaris.

3. Long Period Variables

Inequalities in Period.-- Long period variables are represented in the left column of Fig. 40. They are stars in which the short period variation due to rotation has not yet been differentiated in their spectrograms or light curves. The quantitative momentary increase or decrease in luminous particles poured into their radiating shells, however, is of immediate effect in changing their luminosities. The likeness of their respective activities to those in the sun is evident in the similarities of their light curves to each other and to the sun-spot curve. The inequalities in the length of period in these stars coincide with those of the sun-spot cycles.

Omicron Ceti puts on a new belt of luminous particles at intervals of $332\pm$ days. The activity incident to the acquisition continues with diminishing intensity throughout the period. The radiating shell, obviously, is of much lower luminosity than the particles periodically added to it, so that changes in the rate of their

acquisition are at once effective in changing the rate of the star's radiation. The physical changes implied in the star's change of spectrum during a cycle of light variation coincide with those anticipated from these deductions. As in the sun, the star's eruptive activity is modified by body vibrations whose manifestations are apparent in the humps of the second branch of its light curve.

T Cassiopeia exhibits a curve whose variations are such as to indicate that the reactions to which they are due are similar to those of Omicron Ceti. After the first maximum, however, the forces of eruption are so great as not to be lowered by the rarefaction which follows the first condensation set up within the star. When this sustained maximum is reinforced by the succeeding condensation, the curve is pushed up into the hump which precedes the star's rapid decline to minimum. Physical conditions in a tenacious surface homeoid would account for the deviations from an exact solar type of reaction.

Nova Aurigae presents a light curve, significant features of which are the sinuosities which appear in the position of the secondary condensation in the course of its body vibration. It will be recalled that a line passed vertically across Maunder's chart, Fig. 16:D, at the point of this secondary maximum crosses both rarefaction and condensation. The deviations in the curve of Nova Aurigae are traceable to corresponding reactions resulting from these indicated anomalous internal interferences. The nebulosity found about novae may be taken to indicate that the particles ejected at former epochs attained a wide distribution due to the high tangential velocities of their ejection.

Nova Persei serves well as an example to illustrate the phenomena associated with the nebulosities about novae. The significant features of the Nova Persei field as photographed at the Yerkes and at the Lick Observatory are shown in Fig. 41. The configuration, N, is taken to be the center of mass of the matter involved in the eruptive activity in this field. The "spear-head", B, is found to have been moving forward, while at the same time it was joined to A by a stream of nebulous matter in a continuity easily traceable in the arc, AB.

These relations point inevitably to A as the point of eruptive origin of the "spear-head", B, and of the nebulous matter in its wake. The configuration, A, is therefore not a star in the field but the point where the erupting column penetrates the Nova's radiating shell. Its luminosity, therefore, is dependent upon a continued ejection of luminous particles. Reactions due to the intense magnetic field superinduced by the motion of the electrified stream, AB, added an appendage of particles to the configuration, otherwise circular, at N.

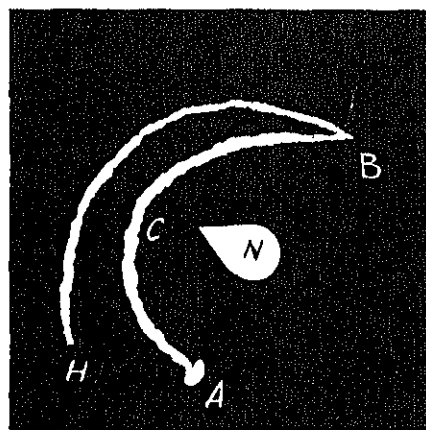


Fig. 41.— Nova Persei

The apparent near approach of AB to N at the point, C, is an effect of perspective due to the high inclination which the plane of the arc, AB, has with respect to the plane of photographic projection. A continuous stream, HB, lies farther out than AB and is, quite obviously, the material of a former eruption which once occupied the position of the nearer stream. Since its formation it has moved outward to its present position. Undoubtedly, other similar parallel streams, the products of earlier eruptions, lie still farther out but are too faint to be of record on photographs of the region.

The spectroscopic changes to be anticipated from this analysis correspond in a significant degree with those actually observed. The erupting stream, emerging from A, rises to a greater visibility above concentric shells of non-luminous, light absorbing matter and finally overspreads the star's radiating surface with an outer

shell of luminous particles. As the nova approaches maximum, the spectrum of its erupting column is modified by the absorption effects of the non-luminous matter intervening between it and the observer.

The eruptive expansion of the stream gives to the intervening dark matter a high velocity of approach which produces a shift of the star's absorption lines toward the violet end of the spectrum. When the stream eventually emerges to an unobstructed visibility above successive shells of light-absorbing matter, it yields an emission spectrum with its lines in normal positions. The changes thereafter in the star's spectrum are those incident to a wide separation of the stream's component particles before their incorporation as an outer concentric shell of the nova. In this distribution they become the chief source of the star's luminosity yielding the characteristic O-class spectrum with bright emission lines. Stars of this type are few in number because, as their spectra indicate, they undergo relatively rapid physical changes incident to the incorporation of their newly acquired surface particles as constituents of the radiating shell.

4. Short Period Variables

Significant Features.-- The similarities which obtain in the short period curves of Fig. 40 indicate that the reactions which yield the variable light curves are fundamentally the same, while the differences they exhibit carry the implication that the activities are subject to external modifications by envelopes of particles peculiar, respectively, to each star.

The angle of ascent is equal to the angle of descent in each curve, but from one curve to the other, they differ. In the curve of Eta Aquilae the upper broken line section, supplied hypothetically, represents the actual physical activity of the star at this phase of its period. The partial obscuration of the phenomenon from the "Observer" through the second phase of the activity, due to an intervening stellar atmosphere or envelope, accounts for the dwarfed condition of the branch of the curve that follows the secondary minimum.

The ascent and descent to a secondary minimum at the center are at similar angles in each curve. The slopes of Algol's curve are greatest, those of Eta Aquilae, least. The deviation is traceable to a more obscuring atmosphere and to a denser enclosing sheath in an erupting column of greater length in the latter star. Not until its erupting column attains a position of complete orientation toward the observer, as at a and b, does the light of Eta Aquilae rise to a full maximum.

The erupting column responsible for the Algol variation is comparatively short. Its reappearance at a, after occultation, results in an almost instantaneous rise to a sustained maximum. The slight depression at the center of the curve indicates that its erupting column is but a little less luminous in a horizontal than in a vertical position. The deep depression at the center of the U Pegasi curve implies a much greater obscuration of the light when the erupting column is in a horizontal position, as at c. The symmetrical reversal of the curves at the middle of the cycle is unmistakable evidence of a recurrence in reverse order of the activities, respectively, for which the branches stand.

A Continuous Reorientation.-- The celestial body whose north pole is N, Fig. 40, was drawn to show the relationship of the rotating star to the light curves above it. When the erupting column is approaching and passing the position, a, the light of the star will undergo changes, of which an increase in intensity is but one feature. The physical deviations incident to the column's changing orientation and to its being seen through varying depths of intervening stellar envelopes, will be of spectrographic record. When the column attains the position, c, perpendicular to the line of sight, differential velocities with respect to the observer will become zero, and a change in the star's physical aspect will be of record in its spectrum incident to the prostrate position of the column and to the greater depth of stellar atmosphere through which it is seen.

When the column passes through the position, b, a velocity of recession will be indicated by the light from its core,

modified by its passage through an overlying stellar atmosphere of greater depth than at a. Where variations in light are found, such as may be represented by the short period curves, characteristic radial velocity changes and physical alterations will be of record in the star's spectrum.

Beta Lyrae is a star, the enigmatic manifestations of whose phenomena the deductions of this hypothesis reduce to a logical causal sequence. The two maxima, corresponding to the positions, a, and b, are of constant brilliancy. The change in magnitude from 3.4 to 4.4 between maximum and minimum brightness, corresponding to the position, d, is constant. The secondary minimum, however, corresponding to the position, c, exhibits variations from exact recurrence in respect to period, luminosity, and physical constitution. The period of Beta Lyrae is lengthening at a mean rate of one second for every three cycles of activity. The change in period is no passing phase of the star's phenomena, as it has been under observation for 100 years.

The spectrum of Beta Lyrae is predominantly that of helium, although calcium and magnesium lines attain prominence. The spectrum is composite and its emission lines as a group move with respect to its absorption lines in coincidence with the period of light variation. The emission lines are from the core of the erupting column as, with the star's rotation, it exhibits changing phases of orientation to the "Observer." The group of absorption lines is from the star's enclosing envelopes and their spectrum changes conform to the implications of the disturbing penetration of an erupting column undergoing continuous reorientation.

The pattern of spectral lines at the secondary minimum and that of the maximum which follows it are much alike in exhibiting heavy absorption lines, while that of the preceding maximum corresponding to the position, a, differs from them in presenting emission lines of prominence. The relative shifts in the spectral lines corresponding to the positions, a and b, confirm the implication of a projection toward the "Observer" at a and away from him at b.

Algol fulfills in every particular the essential impositions of the Hypothesis of Eruptions. The significant similarities in its light curve to those in the respec-

tive light curves of the other stars of Fig. 40 indicate that their variations are due to the same basic cause. The star's period, which should be constant on the basis of orbital motion, varies in such a manner as to invalidate the eclipse hypothesis as a possible cause of its light variation. Since Algol has been under observation, its period with respect to an exactly recurring cycle has lengthened to the extent that in 1843 the cumulative error was 156 minutes. Obviously, the activity that produces a lengthening period in Beta Lyrae gives Algol its increasing length of period. This phenomenon, common to the two stars, identifies their variations as traceable to similar fundamental reactions.

Eta Aquilae may be regarded as an exemplary of the group of stars in each of whose radiating shells an erupting column is seen as of conspicuous visibility, only when it is oriented by the star's axial rotation so as to be directed toward the "Observer", as of the position, a. Such a voluminous sheath of surface particles encloses the core of the erupting column when it is otherwise directed, and such an intervening depth of stellar envelopes absorbs its light, that as the star's rotation brings the erupting column successively to c and b and onward to d, its light curve continues its declination toward its primary minimum, or rises to a suppressed secondary maximum, as in this representative curve. Starting with the erupting column at a, a person attempting to describe the light, the velocity, and the spectroscopic changes that would ensue through a period of axial rotation in a star having a radiating shell sufficiently voluminous to modify its light at a, b, c, and d, as here implied, would find that he was describing in detail the behavior of well-known classes of variable stars.

Cepheid Variables follow such a sequence of description with significant accuracy. The light curve of a Cepheid rises by a steep slope and without perturbation to a sharp maximum. It descends by a more moderate slope, often with irregularities, to a minimum, where in some cases it approaches coincidence with the X-axis. Magnitude differences between maxima and minima range from one to two.

The Cepheids become redder as they diminish in brightness, a fact ascertained

by their relative photographic and visual magnitudes. Corresponding to the positions, a and b, the spectrum lines will be shifted alternately toward the blue at maximum, and toward the red in the period corresponding to the second branch of the light curve. The spectra of Cepheids change with their periods, and if the changing conditions of illumination be noted as the erupting column advances from a through c, b, and d, to a continually greater depth of stellar atmosphere, as viewed by the "Observer", the cause will be understood as due to modifications produced by enclosing stellar envelopes of particles. Further, as anticipated, Cepheids exhibit spectra as of a more actinic source at maxima than at minima.

A Universal Cause.— From a consideration of spectroscopic data as derived from stars of different classes, the conclusion is inevitable that their light, velocity, and changing physical aspects are all traceable to a common basic cause originating within the stars. One or another of these aspects may fail of consideration or may not appear in the observations of a particular star. The deviations, however, do not seem to warrant assigning a completely different dynamic explanation to account for the one aspect under which the star is considered.

That the binary hypothesis is not applicable to account for the physical changes in Cepheids and for their coincident light and velocity variations suggests the desirability of calling attention to unexplained anomalies in other binary systems, such for example, as appear in certain spectroscopic binaries and eclipsing variables.

5. The Spectroscopic Binary Hypothesis

Significant Deviations.— A rotating star in single column eruption with the observer in the plane of its equator, as represented in Fig. 40, would exhibit aspects so similar to those of a binary system that, in the absence of definite contradictory data, either hypothesis would account for the phenomena observed. Of the observed changes common to the two hypotheses, motion alternately toward and away from the observer in periodic time as ob-

served in the spectroscope, would be of record. In the case of a rotating star, however, spectrum lines originating in the star's radiating shell would not undergo a change of position with the period. Such unchanging lines are of record in the spectrograms of many stars classified as binaries and constitute an unexplained phenomenon on the binary basis. The reaction of the erupting column would cause a gradual increase in the period of rotation as observed in Beta Lyrae and Algol. The question arises as to the constancy of period in all binary systems.

Rotation as a cause of variability is consistently probable because of the short periods involved in this class of stars.

The component stars in a spectroscopic binary or eclipsing variable are so near together that their eruptive activities would produce magnetic fields of nearly double the strength of that of a single star. It is an open question whether the stars under a double potential at the distances postulated would not undergo a rapid disintegration and their particles be thrown together in a common nebulosity.

The binary systems may not be verified on the presumption that they were derived from a single star due to its contraction, for the classical sequence of figures upon which the implication of such a division is based does not apply to the problem. The sequence in question is derived from a consideration of but two sets of forces; namely, the forces due to rotation and gravitation. No account is taken of the more potent forces of the released energies of the atoms within the star, whose manifestations are evident as eruptive activities and in the motion of electrified particles in the star's magnetic field.

Irregular Variables are stars in which the even flow of electrified particles from a sub-surface homeoid is modified, interrupted, or prolonged by changing surface conditions or by a varying rate in their atomic disintegrating processes. As the tenacity of the star's surface increases while the rate of its atomic disintegrations decreases, intervals of prolonged quiescence will eventually ensue. These in turn will be followed by eruptions of an intensity proportional to the tenacity

of the surface homeoid in maintaining and prolonging a state of forced equilibrium preceding an eruption. The eventual outburst will involve the celestial body in a successive series of intense condensations and rarefactions, with corresponding sudden increases in luminosity as its electrified particles attain the surface.

6. Visual Binaries

Density of the Companion of Sirius.-- When ionized, electrified particles from the core of an erupting column become the source of light in a star under spectroscopic examination, with the particles composing the radiating shell of such low luminosity as not to be of record, the condition will be certified in the spectroscopic by a single-group spectrogram of emission lines whose positions certify to the electrified state of the source. If the lines are shifted from their normal positions and the star has a zero radial velocity with respect to the earth, the radial velocity determined by the line shifts will be that of the component of velocity of ejection toward or away from the observer.

In a star which has this type of spectrum, the actual area of luminosity will be but a small fraction of the total area of the star. The electrified stream will have been projected through the star's obscuring envelopes and become a light source of limited area above them as of H, Fig. 40.

The mass and brightness of an ordinary star have been connected by a relationship which ascribes a uniform rate of radiation per unit area to the star's surface. This procedure appears to be admissible in the sun and in stars whose spectra certify to a uniform surface luminosity. But the spectrum of the companion of Sirius is an emission spectrum the pattern of whose lines identify its light as emanating from the core of an erupting column and not from the radiating shell, or surface of the star. The assumption that the ionized particles, which constitute the source of luminosity in the companion of Sirius, are distributed uniformly over the star's surface, is as unwarranted as would be the assumption that the calcium light in the sun, as represented in B, Fig. 17, or the white

particles in the southern belt of Jupiter, B, Fig. 19, or the white spots of Saturn were so distributed.

This inadmissible assumption is made, however, in determining the great density of the companion of Sirius. The resulting abnormal density derived for the star represents an actual discontinuity in nature and constitutes one of the anomalies of modern astronomical discussion. Astronomers might do well to give some attention to the principle, "Reductio ad Absurdum", in considering cosmic problems.

According to the Hypothesis of Eruptions the luminosity of the companion of Sirius is derived from a stream of electrified particles which penetrates all the envelopes of the star from which it is derived, and of which the "Observer" has an unobstructed view as of the position, H, Fig. 40. The radial velocity of +20 Km derived from its spectrograms is the radial component of velocity of ejection of particles with respect to the "Observer."

Light Source Outside the Center of Mass.-- Electrified particles at H, Fig. 40, yield up their luminosities at a rapid rate as the stream expands. Its particles, in a state of wide distribution, eventually move along gravitational lines of force and become incorporated as constituents of the star's enclosing envelopes. It is evident from the spectrum of the star that the particles added do not contribute to the luminosity of the radiating shell in amounts sufficient to make it conspicuously luminous; otherwise the spectrum would be composite.

The star's effective source of light, therefore, will be the crown, H, of its erupting column. This point may be, let us say, fifty million miles--more or less--from the center of mass of the companion, the distance HN. It follows that the point of light observed in the visual double-star observations of position angle and distance, from which the companion's orbit is computed, was not in coincidence with the star's center of mass when the observations were made, but at a distance from it depending upon the state of the star's eruptive activity. Slow axial rotation, in this case, will cause the source of luminosity, H, to describe a revolution about the center of mass at the distance, HN, as the star moves forward in its orbit.

The Orbit, A Sinuous Curve.--- Instead of a smooth path, one made up of a succession of sinuosities may be anticipated as the point of luminosity in its rotation about the companion alternately approaches and recedes from Sirius. A short arc of outward curvature is drawn through the plotted positions which mark the points of outward inflection in the two orbits represented in Fig. 42 and 43.

The points of outward curvature are near together where the orbital motion is slowest; distances between successive points of inflection are greatest where the orbital velocity is high. The interval of time required, for example, to describe the 80-degree and the 25-degree arcs, indicated in Fig. 42, are equal. It is evident that the sinuosities characteristic of a 25-degree section of the path will become less conspicuous, if not completely obscured, when they are extended over an arc of 80 degrees.

It will be observed that the points of outward inflection in the orbit of Xi Ursae Majoris have a distribution along the curve similar to those in the orbit of Sirius. Where the orbital speed is least the sinuosities are crowded together and present short arcs and sharp angles to the ellipse of reference; in the section where the orbital speed is greatest, the observed positions lie on a curve smoothed out by an increase in scale along the ellipse of reference. In specific terms, the 140-degree and the 35-degree arcs of Fig. 43 are characteristic of their respective orbital velocities; they are described in equal times.

In using Burnham's figure giving the plotted positions of the companion of Xi Ursae Majoris, I have inserted the broken line ellipse, to serve as a curve of reference, with respect to which the plotted positions are discussed.

Recurrence.--- The axial rotation period of each companion star may be determined by writing in column from the respective figures, the times corresponding to the successive points of outward inflection and taking their differences as follows:

Recurring Periods

Sirius		Xi Ursae Maj.	
Year	Period	Year	Period
1863		1745	
1866	3	1850	5
1870	4	1855	5
1873	3	1860	5
1876	3	1865	5
1880	4	1870	5
1884	4	1876	6
1888	4	1881	5
Mean	3.6	1886	5
		1892	6
		1897	5
		1903	6
		Mean	5.3

If the radiating shell concentric with respect to the center of mass were luminous, the companion star would present two sources of light: one at the center of mass, the other at the crown of the erupting column. Since the two sources are at distances from each other great enough to yield measurable perturbations, they should be seen, under favorable conditions, as a close double-luminosity. It

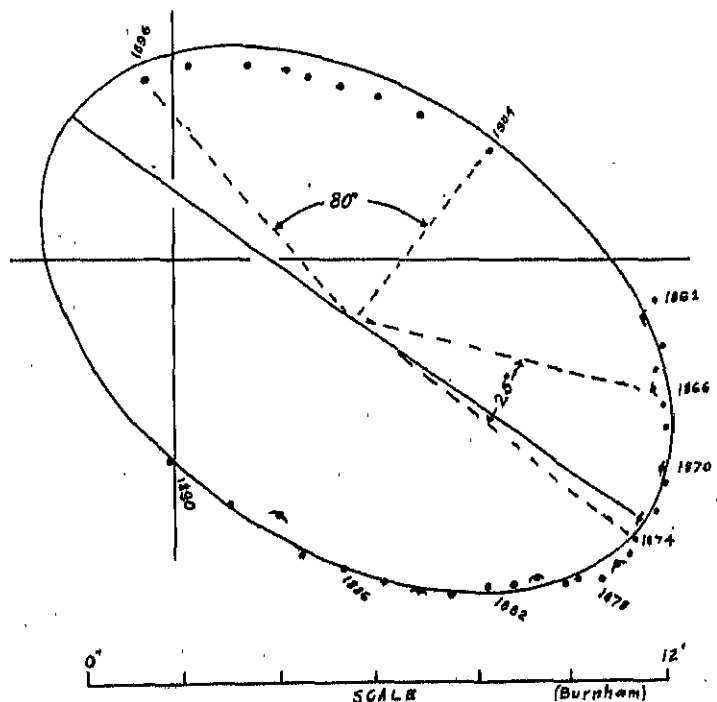


Fig. 42.-- Orbit of Sirius

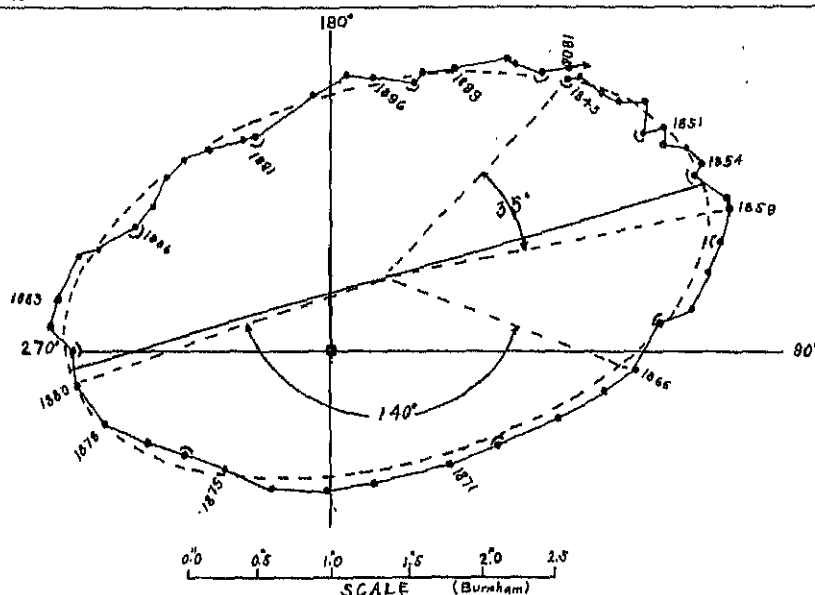


Fig. 43.-- Orbit of Xi Ursae Majoris

is significant to note in this connection that the companion of Sirius has been observed as double by several observers--by Philip Fox in 1920, and by R. T. A. Innes and his associates both in 1926 and in 1928.

The Orbit.-- What path the companion actually follows in describing its revolutions about Sirius has received a great amount of consideration from astronomers. With regard to it Burnham makes the following statement in his, General Catalogue of Double Stars: "In 1851 Peters calculated the theoretical orbit of the disturbing body which would satisfy the observed places of Sirius to that time, and, so far as appears, the period thus found is as nearly correct as that of any modern computer from visual observations of the real star during nearly forty years."

That the orbit is a problem not without its difficulties is borne out consistently in the statement of Newton M. Mann, Popular Astronomy, IV, 482. "That the orbit of Sirius presents problems not easy of solution, they who have given much attention to it do not need to be told. The law of parsimony leads to the greatest effort to reach a satisfactory result which will involve only the two visible

objects. With others who have worked to that end, I am satisfied at last that it cannot be reached. Such result as I have been able to arrive at after a good deal of labor is now submitted, not as a definite conclusion, but as an approximation to what may be called the mean orbit. I have before me, awaiting cremation, some twenty other results differing slightly from this and from one another, some of which, reached by a more determined effort to obliterate the signs of perturbation, show what, at first sight looked like a better comparison with the observations; but a closer scrutiny led me to

reject them, and to fall back upon what is here presented, which frankly admits a perturbing influence in the system."

Recapitulation

A radiating celestial body is subject not only to rotation, and to a gravitational field of force, but also to a strong magnetic field. A loss of radiant energy produces changes in the three potentials and in the body's state of electrification. The astrophysical problem with regard to such a body consists, not in stating what will be the behavior of matter in one or the other of these fields, taken separately, but in giving the modifications which must follow as a result of its being subject, under varying conditions of electrification, coincidentally to all the fields involved.

The radiant energy of celestial bodies is derived from their disintegrating atoms.

The luminosity of a star depends upon the streams of electrified particles which are being poured from the interior into the radiating shell continuously, or projected through it to form an unobstructed luminosity outside the star's outermost photospheric envelope.

ERRATA

Page

- 9 1st column, 5th line from bottom -- insert after
1st "form and characteristic internal motions,
The superheated,"
- 11 2nd column, 17th line from bottom -- "character-
istics" should read "characteristic."
- 16 2nd column, 1st line -- should read "observato-
ries, of Paris, Yorks, etc."
- 18 2nd column, 18th line from top -- change "views"
to "cases."

Figures 251D and 271D -- insert at bottom of page "By
Permission of the Publishers, Relief Map from
HUMAN GEOGRAPHY by J. Russell Smith; Copyrighted
by the John C. Winston Company."

Page

- 16 2nd column, 17th line from bottom -- change
"lighter" to "lighter."
- 60 2nd column, 18th line from top -- change "pole"
to "polar."
- 61 1st column, 18th line from bottom -- change to
read sublocation.
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